SOLENOPSIS (*DIPLORHOPTRUM*) (HYMENOPTERA:FORMICIDAE) OF FLORIDA

By

Catherine R. Thompson

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Prior to this study, six species of the subgenus *Solenopsis* (*Diplorhoptrum*) were reported from Florida. In the present study, four new species were found in the state. New information on *S.* (*Diplorhoptrum*) prevalence, mating flights and role as predators was obtained.

Review of the literature on *Diplorhoptrum* indicated that these were thief-ants, present in relatively small numbers in the soil, and usually in close association with nests of larger ants. Use of unique, baited traps revealed *Diplorhoptrum* in unexpectedly large numbers with a wide distribution in the soil. The ants were present in all but extremely hydric habitats in Florida.

In this study, eight species of *Diplorhoptrum* were found: six subterranean species, and two arboreal species. Four species previously reported from Florida were not found. Examination of available voucher specimens showed these to be misidentified. It seems possible that authentic specimens of some of these species will eventually be found

in Florida. Independent studies have shown that the venom of one of the new species contains (5Z,8E)-3-heptyl-5-methyl pyrrolizidine, the first recorded occurrence of this substance in any animal or plant.

In subterranean studies, 50 traps each in an open field and a long leaf pine-turkey oak woods were baited each month for a year. Five Diplorhoptrum species came to the traps, three of which were new. The dominant species in both habitats was S. (D.) carolinensis, while S. (D.) pergandei was found only in the woods site, and the remaining species were present in both habitats. The nest locations and foraging territories were mapped and found to have mosaic patterns. Ant activity nearly stopped between October and November and did not reach high levels again until the following May. Soil temperature is probably a major factor in this activity pattern. May soil temperatures were five to seven degrees higher than those in April.

The only Diplorhoptrum species which constructed nest structures at the soil surface was S. (D.) pergandei. These structures were crenelated tumuli constructed for mating flights. The tumuli apparently allow more sexuals to remain near the soil surface and also provide a surface for flight takeoff. Mating flights for this species took place one half hour before dawn from June through August, mostly when there had been rain in the previous 24 hours.

The predatory activities of Diplorhoptrum were studied. They readily killed and consumed newly mated imported fire ant queens, Solenopsis invicta Buren. Several Diplorhoptrum species were also found to kill and eat the larvae of the Sugar Cane Rootstalk Borer, Diaprepes abbreviatus (L.). The indications are that Diplorhoptrum species may be important subterranean predators and should be further investigated for their potential as biological control agents.

INTRODUCTION

There are approximately 8,000 known taxa of ants in the world, and the habits exhibited are extremely diverse (Wilson, 1971). Three principal ecological types may be said to exist in the Formicidae. These are: I. Arboreal species, ants which nest in trees and forage for food or obtain their food in trees or non-aborescent plants, II. Terrestrial ants which nest in the soil and forage for food mostly on the soil surface, and III. Subterranean or cryptobiotic ants, ants that nest and forage underground or beneath debris seldom coming to the soil surface. Species may, of course, occupy more than one of these habitats.

Cryptobiotic ants are interesting academically because they often are highly modified structurally . Ants of the generally cryptobiotic tribes Dacetini and Basicerotini, as well as other aberrant genera, have been described and figured in many papers, of which Brown (1962), Brown and Kempf (1967), Brown (1974) and Brown (1977) are examples. The highly modified structures of these ants probably adapt them for specialized predation on soil arthropods and are fortuitously useful in taxonomic studies.

Subterranean ants are generally thought to be lestobiotic. Solenopsis (Diplorhoptrum) as well as related subterranean genera such as Oligomyrmex, Carebara, Carebarella are also more generalized in structure. They have few specialized features which makes them

difficult to study taxonomically. Whitcomb et al. (1972) and Buren et al. (1977) suggested that this group of genera and species might be much more important as generalized subterranean predators than had been previously suspected, and that their role in lestobiosis might be secondary.

These studies were undertaken as an investigation into the abundance, ecology, taxonomy, and predatory importance of these ants in Florida. The data will revise thinking on the importance of these predators in the subterranean ecosystem. The study also helps to emphasize the need for similar studies on a world-wide basis.

REVIEW OF LITERATURE

Taxonomy

The genus *Solenopsis* is essentially cosmopolitan and is found in all but the coldest parts of the world. The genus was divided by Creighton (1950) into three subgenera: *Solenopsis*, *Euopthalma* and *Diplorhoptrum*. The painful stings inflicted by members of the *Solenopsis* (*Solenopsis*) group have attracted public attention as the red Imported Fire Ant *Solenopsis invicta* Buren continues to spread in the southern and southwestern U.S.

While not endearing themselves to the general public, the genus *Solenopsis* is also no favorite of ant taxonomists. Creighton (1950) grumbled "The student of North American ants may count himself fortunate that so few species of this difficult genus occur in our latitudes" (p.226). The worker caste in *Solenopsis* has undergone extreme convergence, making identification to species difficult. Unfortunately most of this convergence has occurred in *Diplorhoptrum*.

The taxonomic postion of *Diplorhoptrum* is subject to discussion. Ettershank, in his revision of the Solenopsini (1966), synonymized *Diplorhoptrum* under *Solenopsis*. Baroni-Urbani (1968) resurrected the group and gave it full generic status. Unfortunately he based his determination on the male genitalia of the common European species, *S*. (*D*.) *fugax* (Latreille), without knowledge of the Neartic and Neotropical fauna. Although Creighton suspected that male and female

morphology may indeed be the only reliable source of characters on which to base Diplorhoptrum taxonomy, the fact remains that at present few of the males are known. For this reason American myrmecologists have been reluctant to accept Baroni-Urbani's work (pers. comm., W. F. Buren). Retaining Diplorhoptrum as a subgenus may be acceptable simply for convenience: as a group Diplorhoptrum are usually small, monomorphic species as opposed to the larger, polymorphic, free-living fire ants (MacConnell et al., 1976). All S. (Diplorhoptrum) species have the 2nd and 3rd joints of the funiculus distinctly broader than long, whereas in S. (Solenopsis) and (Euopthalma) species these joints are longer than broad.

To search the literature on Diplorhoptrum, one must be aware that the species most frequently published upon, S. (D.) molesta, is also found under five synonyms: Myrmica molesta Say, Myrmica minuta Say, Myrmica exigua Buckley, Solenopsis debilis Mayr, and Solenopsis molesta (Say).

There has been an unfortunate tendency to identify every small yellow thief ant as S. (D.) molesta. The problem is compounded by the fact that S. (D.) molesta is the only economic pest in the Diplorhoptrum group. As a result much of the literature concerning S. (D.) molesta may be based on misdeterminations.

Distribution

Creighton (1950) listed 12 taxa of Diplorhoptrum for North America. The most recent compilation (Smith, 1979) also contains 12 taxa: 10 from Creighton's original list, one species renamed, and one placed in synonomy. At least one Diplorhoptrum species has been reported

from each of the contiguous 48 states with _S_. (_D_.) _molesta_ (Say), the most widespread species, reported from 30 states. The species reported from Florida are _S_. (_D_.) _molesta_ (Say), _S_. (_D_.) _pergandei_ Forel, _S_. (_D_.) _picta_ Emery, _S_. (_D_.) _tennesseensis_ Smith, _S_. (_D_.) _texana_ Emery, and _S_. (_D_.) _truncorum_ Forel.

Economic Importance

Although not as notorious as their fire ant relatives, _Diplorhoptrum_, or thief ants as they are commonly called, contains one species, _Solenopsis_ (_Diplorhoptrum_) _molesta_ (Say), which is a pest in fields and dwellings. As a result of this pest status, and erroneous identifications, most of the literature deals with this species. Although Creighton (1950) reported it to be distributed only in the central and eastern states, it has subsequently been reported from eight of the 11 western states (Appendix).

_S_. (_D_.) _molesta_ is best known as a economic pest of sorghum. The ant is known as the "kafir ant" in Kansas (Bryson, 1941; Hayes, 1925) where it has been called the single most damaging pest of planted sorghum (Burkhardt, 1959). The ants diminish sorghum stands by feeding on germinating sorghum seed (Young and Howell, 1964). They have destroyed thousands of acres of sorghum necessitating one to six replantings and then not always with a resultant full stand (McColloch and Hayes, 1916). Srivastava and Bryson (1956) found that tilling the soil, planting early, and using various insecticides or insecticide-fungicides prior to planting helped avoid damage. All of the compounds tested were effective, while the ants damaged 50% of the check seeds. McColloch and Hayes (1916) found that only late plantings were

damaged. Early planting, along with seed treatment, fall plowing, and surface planting have essentially eliminated the kafir ant problem.

S. (D.) molesta has been reported to eat out the interiors of corn kernels, and in New York is known as the "little yellow ant" (Fitch, 1856) and the "yellow field ant" (Felt, 1916). There are reports of strawberries (Fitch, 1920) and blackberries (Webster, 1893) damaged by S. (D.) molesta. This ant may also indirectly damage crops through its habit of tending various species of aphids (Landis, 1967; Smith & Morrison, 1916; Webster, 1893). It attacked the cocoons of the Japanese beetle parasite Tiphia and killed 20% in the laboratory (White, 1940). Smith (1965) reported S. (D.) molesta as a host of a poultry tapeworm.

S. (D.) molesta is one of only two of our native ant species which invades homes (Wheeler, 1910). Herrick (1921) reported on the "little fiery ant" which invaded kitchens. While Forbes (1896, 1920) and Fitch (1856) stated that this ant had a sweet tooth, Back (1937) said that it fed "almost entirely" on greasy substances. It is possible that a number of Diplorhoptrum species may be involved. S. (D.) molesta validiuscula Emery is a common pest in California homes where it lives in crevices around sinks and feeds on greases, meats, and cheese (Mallis, 1941). Among the more curious of S. (D.) molesta dietary preferences was an insect collection (Fitch, 1856) while an artist complained that S. (D.) molesta was eating his paints (Webster, 1893).

Nearly as many reports in the literature point to S. (D.) molesta as a valuable predator as malign this species as an economic pest. Brooks (1906) observed S. (D.) molesta in large numbers feeding on grape curculio, Craponius inaequalis (Say), larvae. The ant killed

walnut curculio larvae, Conotrachelus juglandis Lec., in young black walnuts on the ground (Brooks, 1910). It attacked boll weevil larvae, Anthomomis grandis Hubner (Hunter & Pierce, 1912; Hunter & Hinds, 1904; Pierce, 1912) was observed carrying chinch bug eggs, Blissus leucopterus (Say), (Headlee & McColloch, 1913) and eggs and small larvae of the cabbage maggot Phorbia braassicae Bouché (Schoene, 1916). In studies on the striped earwig, Labidura riparia (Pallas), spraying heptachlor to control S. (D.) molesta appeared to increase earwig populations. S. (D.) molesta was subsequently observed feeding on earwig eggs in experimental field plots (Gross & Spink, 1969).

S. (D.) molesta seems to be particularly important as a predator on codling moth, Carpocapsa pomonella Linn., larvae and pupae (Brooks & Blakeslee, 1915; Jaynes & Marucci, 1947). The workers cut small characteristic holes in the cocoons, accounting for 2.5 to 64.2% of all attacked cocoons. Those near the colony site were killed by the ants in 2-5 minutes. S. (D.) molesta is listed as a predator in Arkansas cotton fields (Whitcomb et al., 1972; Whitcomb & Bell, 1964). S. (D.) molesta has been found living with S. invicta and richteri Forel where it was seen eating eggs and early larval instars of S. invicta (Collins & Markin, 1971; O'Neal, 1974). Interestingly, S. (D.) molesta was unaffected by the Mirex bait used to kill S. invicta in Louisiana (Markin et al., 1974). Ayre (1963) fed S. (D.) molesta colonies both live and dead insects of a number of species. The ants consumed 39 of 49 live insects and 53 of 54 dead insects. They also ate eggs of the weevil Sitona scissifrons Say. Ayre concluded that S. (D.) molesta "may be as effective a predator as those species that capture larger insects," but "limited in their choice of food because they are small" (p. 715).

The role of other Diplorhoptrum species as predators is not nearly as clear. Published reports are few. S. (D.) texana was observed attacking boll weevil larvae in Texas, Louisiana, and Mississippi (Hunter & Pierce, 1912). S. (D.) molesta validiuscula Emery was often found attacking codling moth larvae under experimental tree bands in West Virginia apple orchards (Jenne, 1909).

Biology and Ecology

Because Diplorhoptrum species are still in considerable taxonomic flux, there are few published reports relating to the biology and ecology of the species. The bulk of information concerns microhabitat and ecosystem distributions. In Table 1 (Appendix), data on nesting locations of S. (D.) molesta is presented. Although this species seems able to establish colonies in most types of habitats, on the microhabitat level it displays a distinct preference for cover, particularly stones.

What is known concerning the biology of Diplorhoptrum species consists of observations dispersed through the general literature on ants with almost no exhaustive studies. For example, in at least one western state (Utah) S. (D.) molesta validiuscula is considered a dominant Diplorhoptrum species, is 1.3 mm long, lives under stones, bark, and logs (Cole, 1942), and has been observed feeding on chicks, rats, and mice (Eckert & Mallis, 1937). Hayes (1920) has conducted the only biological study of S. (D.) molesta. His thorough study determined life tables for the brood, field colony size, queen egg production, flight information, and methods of laboratory colony maintenance.

One of the most interesting habits of S. (D.) molesta, as well as other Diplorhoptrum species, is lestobiosis. This ant has been found

living beside or with 33 different species of ants of four subfamilies (Cook, 1953; Hayes, 1920; King, 1896, 1901a & b; Mallis, 1941; Mann, 1911a; and Wheeler, 1901). S. (D.) molesta will also live amicably with the termite Reticulitermes flavipes (Kollar) in the laboratory (Smythe & Coppel, 1973). The data on Diplorhoptrum species which are freeliving or lestobiotic are lacking, spotty, or contradictory. While Kennedy (1938) found four nests of S. (D.) texana, all lestobiotic, Wheeler and Wheeler (1963) made 81 collections of which 53 were independent nests. They were unable to determine if the ants were S. (D.) molesta or S. (D.) molesta validiuscula. They found that the independent nests had ¼" dia. chambers as much as 5" below the soil surface, but mostly in the upper 2½". As Wheeler (1901) pointed out, however, there could be long connecting galleries between these species and their suspected host galleries or no relationship at all.

Diplorhoptrum are themselves hosts of a number of guests. Wheeler discovered the first guest, reported only as a Hymenopteran (Brues, 1903). Fall (1920) found a new species of blind beetle Alaudes alternata Fall in S. (D.) molesta nests. King (1895, 1897) observed a mite on larvae which attached midway between the thorax and abdomen and a Staphylinid of the tribe Aleocharini. Schwarz (1890a & b, 1896) found Coleoptera of the genera Lithocharis and Myrmecochara with S. (D.) molesta, but believed the former to be an accidental guest. Wickham found the latter beetle with the ants, first calling it Gyrophaena sp. but later correcting the name (1892, 1894) to Myrmecochara crinita Casey. He felt this species to be a true myrmecophile along with Atheta exilissima Casey. Wing (1951) found a number of wasp guests of the genera Buresopria and Auxopaedeutes, and Loxotropa californica Ashmead.

S. (D.) molesta appears to have few natural enemies, although research lags in this area. Beal (1911, 1912) found that a flicker, Colaptes auratus L. subsp., and the kingbird or bee martin, Tyrannus tyrannus (L.) feed on S. (D.) molesta. No less than 39 species of birds were observed feeding on a mating flight of S. (D.) molesta (Judd, 1901). Diplorhoptrum probably have a number of ant enemies, but only two are reported: Hung (1974) found that 10% (or 80) of the ants' heads in the garbage pile of a Conomyrma nest were those of S. (D.) molesta. Buren et al. (1977) suggest false phragmosis evolved by Pheidole lamia Wheeler serves as a defensive tactic against subterranean ants, mainly Diplorhoptrum.

It is fortunate that two astute observers have published their observations on the mating flights of S. (D.) molesta. In Kansas, Hayes (1925) observed a flight at 5 p.m. on July 27, 1920, which continued until dusk, and a flight July 5, 1921. Both were preceded by heavy rain. He noted that mating occurred in the air, that females outnumbered males (unusual in ants), and that males mated more than once. Farther north in Canada, late August flights occurred (Macnamara, 1945; Wheeler, 1916) and Macnamara observed a dense evening swarm, 3-4 ft in diam. and at its lowest point about 3 ft off the ground. He saw that the swarm was sluggish and noticed, most importantly, that the females were carrying workers on their bodies. Wing (1951) reported that W. L. Brown found approximately 20% of the S. (D.) molesta females in a Philadelphia flight had one or rarely two workers attached to their legs.

Venom Chemistry

Venom chemistry and behavior associated with it have attracted increasing interest and research in the past decade. Jones et al. (1979) identified a new venomous constituent in the poison gland of *S.* (*D.*) *molesta* and *S.* (*D.*) *texana*. The chemical, 2-hexyl-5-pentyl-pyrrolidine, is the first known 2,5-dialkyl pyrrolidine from a natural source. More recently, a new alkaloid, (5Z,8E)-3-heptyl-5-methyl pyrrolizidine has been identified (Jones et al., in press) in *S.* (*D.*) *xenovenenum* n.sp. denoted as a species near *S.* (*D.*) *tennesseensis*. Wilson (1975) studied *Pheidole dentata* Mayr and found a chemical alarm-recruitment system in the minor caste which recruits the majors. It is a chemical which specifically recruits the majors to ants of the genus *Solenopsis*. Holldobler (1973) reported that *S.* (*D.*) *fugax* (Latreille) (European species) has a recruitment pheromone produced by the Dufour gland and a repellent substance produced by the poison gland. The repellent prevents brood-keeping ants from defending their own larvae against the *Diplorhoptrum*. Blum and Jones (1980) found that the *S.* (*D.*) *fugax* substance repelled 18 species of ants. The secretion of one gland would stop *Lasius flavus* McCook from using a nest entrance for almost an hour. The main component was trans-2-butyl-5-heptylpyrrolidine, a dialkyl-pyrrolidine which is evidently an integral part of *S.* (*D.*) *fugax* raiding strategy.

MATERIALS AND METHODS

Taxonomy

Because the largest Florida S. (Diplorhoptrum) worker is only 1.8 mm long, it is imperative that anyone wishing to study this group have at their disposal a microscope with a minimum of 40 diameters of magnification. The Wild® microscope used for this study was also equipped with an ocular micrometer.

Traditional measurement techniques were utilized and specimens were compared with types at the U.S. Natural History Museum in Washington, D.C., and the Museum of Comparative Zoology at Harvard University, Cambridge, Mass. Measurements of specimens and indexes calculated were as follows:

1. Head width: greatest width of the head in full face view.
2. Head length: greatest length of the head in full face view, but excluding the mandibles.
3. Head index: $\frac{\text{Head width x 100}}{\text{Head length}}$.
4. Head depth: measured on line running through the eye and perpendicular to line running from just above mandibular insertion to point where neck meets thorax.
5. Thoracic length: greatest length of thorax in lateral view.
6. Scape length: middle of antennal socket to tip of scape.
7. Scape index: $\frac{\text{Scape length x 100}}{\text{Head length}}$.
8. Funiculus length: tip of scape to tip of funicular club.

9. Club length: length of last 2 antennal segments which form the typical club.
10. Body length: total length of specimen from mandibles to tip of the gaster. This measurement cannot be made as accurately as the others. Specimens were so rarely in a natural position on the pins that only a rough estimate was made of total body lengths.
11. Eye length: greatest length of the eye.
12. Eye index: $\frac{\text{Eye length x 100}}{\text{Head length}}$

Specimens studied were obtained from as many locations as possible in Florida. Series collected by D. P. Wojcik (USDA, Gainesville, Florida) and by A. F. Van Pelt (collections in the Florida State Collection of Arthropods, Gainesville, Florida) and Dr. William F. Buren (Dept. of Entomology and Nematology, Univ. of Florida, Gainesville, Florida) were studied.

Lactophenol Fixation

A novel method for taxonomic study of ants was use of slide-mounted specimens prepared by a four minute lactophenol fixation process (Esser, 1973) initially developed for nematode studies. This rapid procedure cleared specimens and allowed particularly detailed study of pubescence.

1. The ants were removed from alcohol and placed in water in a watch glass set inside a petri dish on a hot plate.
2. The specimens were heated to 370°C and lactophenol added until the watch glass was full.

3. The specimens were heated an additional two minutes then were cooled 10 minutes.
4. A ring of "zut" (Thorn, 1935), a sealant used to mount helminths, is placed on a slide. The ring is built up enough to avoid crushing the specimens (and requires practice and extra specimens). The ants, in some lactophenol solution, are placed in the ring and a cover slip placed over the ants and the zut.

Having a number of ants per slide ensured that at least one would be positioned correctly for any structure studied.

Scanning Electron Micrography

Diplorhoptrum workers are so small that use of the usual black carbon contact cement was nearly impossible. Split-second timing was needed, otherwise the cement dried or the specimen disappeared under the cement.

These problems were overcome by the use of double-stick white labels. The ants were arranged on the label and pushed into the adhesive. But a problem developed with charging (a process which results in bright light bouncing off the specimen and obscuring structure), even though the specimens had been double-gold-coated at three minutes per coat with a break between coatings to dissipate heat.

To alleviate charging, the ants were placed on the sticky labels and spots of carbon glue were placed near the specimens and smeared into contact with the tarsi or under parts of the body. In this way conduction was increased and charging reduced.

Field Studies

Collecting Techniques

Unlike many terrestrial ant species, Diplorhoptrum have few surface indications of nest location, with the exception of S. (D.) pergandei mating flight tumuli (Figure 29). Diplorhoptrum are nocturnal and, even at night, forage little above ground except in moist areas. As a result, conventional methods were not as effective in locating and collecting these ants; however, the following techniques were utilized with some success:

1. Lifting bark from bases of trees and from rotten logs. Species most frequently obtained were S. (D.) pergandei and S. (D.) carolinensis.

2. Searching for unnatural soil disturbances such as slight mounds and color changes indicating excavations, or for parts of dead insects grouped in one place.

3. Overturning stones, logs, and other soil cover and tearing apart rotten logs.

4. Searching shovelfuls of soil for foragers, particularly in moist areas and along the edges of tree roots. Although this method would seem time consuming and the finding of any ants a matter of chance, it was one of the most effective. One morning's work and nearly 200 shovelfuls produced one S. (D.) carolinensis queen and workers and an additional sample of workers; a second morning's work produced one S. (D.) pergandei queen and colony. In a third area one half hour of work produced two S. (D.) carolinensis queens and colones.

These collections were in different habitats, the first two areas were xeric while the third area was hydric.

Naves Traps

Naves traps (unpublished technique) were baited with honey agar (Bhatkar and Whitcomb, 1970), cabbage loopers, Diaprepes beetle larvae, Fire Ant queens (S. invicta), or most often tunafish. The Naves trap is made by modifying a two ml sidetabbed Dispobeaker® (Scientific Products) as follows: A teasing needle is heated and used to melt 0.5-0.9 mm diam. holes in the cap and bottom of the beaker. Three holes are placed in the cap top, six around the sides of the cap and three in the bottom of the trap body. All attempts to further standardize hole size by wiring a soldering iron with 1/16 inch copper wire failed; the wire would not hold enough heat to melt the plastic. Acrylic red yarn tied around the trap under the side tabs served as a marker and means of pulling the trap from the ground.

A narrow bladed trowel (5 cm at greatest width) was used to bury the traps with their bases at a depth of 14 cm. It was found that less than 10 cm depths resulted in traps filled with fine sand which sifted through the trap tops in dry soils. Depths of 18 cm or more made trap recovery and replacement of the soil difficult. The 14 cm depth was chosen as an average and employed throughout trapping experiments as an experimental constant.

As a note of caution, even the small holes of these traps did not exclude a number of other ant species: Pheidole metallescens Emery, Brachymyrmex depilis Emery, Pheidole dentata Mayr, and P. floridana Emery. Other less frequent species were Ponera pennsylvanica Buckley

and a Strumigenys species. In areas infested with S. invicta, the fire ants chewed at the cap holes until they were large enough to gain entrance to the bait. Their chewing habit cost me considerable time in the making of new caps.

Unfortunately, the Dispobeakers® have been discontinued by the manufacturer. Traps have now been made from plastic, cap-attached vials made by Bio-Rad Company. These traps will be utilized in South America studies in the near future but are still in the experimental stage.

Local Distribution Study

Studies of small area distribution of Diplorhoptrum species were undertaken utilizing stratified sampling. A 5 x 10 square meter grid was laid out in a open field at the Gainesville Airport. The field is mowed twice a year, maintaining grasses and occasional young turkey oaks (Quercus laevis Walt.) below 3-4 ft. The area is designated for use only as an emergency runway. A second 5 x 10 square meter grid was laid out in a long leaf pine (Pinus palustris Mill.)--turkey oak woods bordering the northeast side of the open field.

Biweekly (June 1979-July 1979) and then bimonthly (Aug. 1979-June 1980) Naves traps were loaded with tunafish and placed one in the center of each square meter of the grids. The traps were placed at a depth of 14 cm for 24 hours. At the end of 24 hours the traps were taken up. Traps with ants were quickly placed in snap-top vials for later indentification. The square meter was rebaited with another trap. Following 24 hours, the traps were again taken up, positive traps

put in vials, and red marker yarn placed in the soil to mark the bait station until it was rebaited.

Use of Light Trap Collections

During May through August, *Diplorhoptrum* males and females of *S*. (*D*.) *pergandei*, *S*. (*D*.) *carolinensis*, and rarely *S*. (*D*.) *reinerti* are attracted to light traps. Larger collections of *S*. (*D*.) *carolinensis* can be made with a light trap and a white sheet than with a conventional, walk-in light trap. The reason for this is unknown, but possibly a different quality of ultraviolet light is reflected by the sheet, and thus attracts this species.

Laboratory Studies

Colony Nest Materials

Maintaining *Diplorhoptrum* colonies in the laboratory is extremely difficult. Their small size and hypogaeic habits make them highly vulnerable to d~~i~~Esiccation. Workers of colonies in open laboratory pans at 80% relative humidity die within 24 hours. If a colony is presented with a moist chamber within an open laboratory pan, the workers which forage outside the chamber will die in the open pan before they find their way back to the colony. The colony dies by slow loss of foraging workers.

Florida *Diplorhoptrum* species seem to need humidity levels of nearly 100%, in contrast to *S*. (*D*.) *molesta*, and other *Diplorhoptrum* species such as the unidentified Peruvian species in Dr. Ed Wilson's laboratory at Harvard University. This species is kept in a plastic box open to the air. Lower humidity requirements apparently allow

S. (D.) molesta and S. (D.) texana to forage above ground during the day. S. (D.) texana was observed in a late morning expedition to food in a car trunk (July, 1980) at Clinton, Iowa (pers. comm., Dr. W. F. Buren) while I have taken S. (D.) texana at honey baits in full sun (June, 1980) at Cedar Falls, Iowa.

Two materials often used to maintain ant nest humidity are plaster of paris and Castone®. When colonies were placed in petri dishes with floors of either compound, workers began to go into convulsions within a few hours, then died. An entire S. (D.) carolinensis colony died overnight June 3, 1980, while a S. (D.) pergandei colony displayed similar symptoms the following day. The queen died two days after exposure to these compounds, or possibly because of shock due to colony loss. Neither species queen showed convulsive symptoms.

Colony nest humidity was finally maintained by 1) moistened cotton floors, or 2) by using "aged" plaster of paris covering only one fourth of the nest floor. The aged plaster was in old petri dish nests which had been used and repeatedly washed in hot, soapy water.

The small size of the Diplorhoptrum workers allows them to escape from any kind of petri dish. Talc and Fluon® could not be used because of the high humidity levels. When colonies were sealed in with artist's clay, the workers gnawed 0.82 mm holes through the clay and escaped. In colonies sealed with vaseline, many workers died overnight, apparently from fumes given off by this material. Finally the vegetable fat Crisco® was tried. The ants refused to cross the greasy barrier. Crisco® was subsequently placed around the inside rims of petri dishes effectively preventing ant escapes.

When an Iowa S. (D.) molesta colony was placed in a Crisco® barriered nest, however, the workers began to eat the Crisco®--something none of the Florida species had done! The colony is presently housed in a glass jar with a screw-top lid.

Feeding

Colonies offered a selection of foods including 1:1 honey-water, butter, raw hamburger, peanut butter, honey-agar, oil-packed tunafish, fire ant diet (used by USDA, Fire Ant Laboratory, Gainesville, Florida), and mealworms. S. (D.) carolinensis fed upon the honey-agar and tunafish, but largely ignored the other foods. They backed off hurriedly from peanut butter. Mealworm larvae were killed, but did not appear to be fed upon.

Although S. (D.) picta and S. (D.) reinerti accepted fire ant diet and honey-agar readily, colonies of S. (D.) pergandei were reluctant feeders on all offered foods. Fire ant larvae were also offered to this species but were refused, even when the larvae were punctured so that haemolymph exuded. Colonies of this species could not be maintained for more than a few months.

Queen Colony Founding

Young, newly mated females obtained from light traps were initially placed in compartmented plastic boxes. Each compartment had a moistened plaster of paris floor and sides painted with Fluon®. The high humidity allowed the queens to walk over the Fluon®, however, and they congregated in groups. Of 36 S. (D.) carolinensis, 45 S. (D.) pergandei and two S. (D.) reinerti females, eight S. (D.) carolinensis no S. (D.) pergandei and both S. (D.) reinerti queens reared brood to

the worker stage. No S. (D.) pergandei queen was able to found a colony. Some queens laid eggs and had larvae, but died before workers were reared.

Other materials and methods were then tried:

1. Glass tubes with moistened cotton.
2. Aged plaster of paris bottomed vials with soil above the plaster and black paper for cover.
3. Cores of grass sod placed in vials, allowing excavation and a more natural environment.
4. Placement in queenless laboratory colonies.

Methods 1-3 were unsuccessful. Method 4--addition of queens to queenless colonies--ended inconclusively. The females were initially seized by the legs and antennae, but subsequently were released and allowed to stand over the brood. Of 12 females added, six had died before the colony had to be left unattended for two weeks. The colony died during that time.

In summary, no satisfactory method was found for inducing queen colony foundation in S. (D.) pergandei. Presenting young queens with brood or callows of their species will probably prove to be the most useful method.

Queens of S. (D.) carolinensis found colonies readily in plaster of paris cups if they are allowed to remain together in groups. Queens of S. (D.) reinerti founded colonies easily alone. It was, in fact, the unexpected yellow workers reared by these black queens that first convinced me that they were a new species.

RESULTS

Section I
A Taxonomic Review of the S. (Diplorhoptrum) of Florida

Introduction

No taxonomic progress has been made in the *Solenopsis* (*Diplorhoptrum*) group for a number of years. The most recent species to be described was *S.* (*D.*) *longiceps* by M. R. Smith in 1942. This species name was subsequently found to be preoccupied by *Solenopsis longiceps* Forel, and was changed to *S.* (*D.*) *tennesseensis* M. R. Smith in 1951. The most recent taxonomic key for the group is that by Creighton (1950) in which he tried to define the group and synonymized several names.

Because of taxonomic and identification difficulties, most workers have been lumping any *Diplorhoptrum* specimen under *S.* (*D.*) *molesta*. This species, in fact, is supposed to occur in Florida, but I have not collected it anywhere in the state. The situation is not improved by the fact that all of Say's types, including those of *S.* (*D.*) *molesta* (Say), have been lost.

When a small, 100-meter square area in Gainesville was sampled and three new species were frequently recovered, it was very apparent that taxonomic work was needed. This study will help to prevent the "band-wagon" effect, which has gone on for many years, of labeling any *Diplorhoptrum* specimen *molesta*. It will fill the gap left by Van Pelt (1947) who purposely omitted the group from his Florida key because of their uncertain taxonomy.

The four new species found during this study have the proposed names of S. (D.) "abdita" n.sp., S. (D.) "nickersoni" n.sp., S. (D.) "reinerti" n.sp. and S. (D.) "xenovenenum" n.sp. (Names proposed here in quotation marks are not to be considered validly or effectively published for nomenclatural purposes.)

Key to S. (Diplorhoptrum) Species of Florida

1a) Mesopropodeal constriction strong (Fig. 21); promesonotum and propodeum, in profile, strongly convex; petiolar node placed somewhat anterior to the petiolar-postpetiolar juncture (Fig. 23) so that the petiole has a distinct slender posterior portion; color uniformly dark brown or black including the appendages; an arboreal ant found nesting in twigs and small branches of various trees. . . . . picta Emery

b) Lacking above combination of characters; mesopropodeal constriction not as strong; promesonotum and propodeum never both strongly convex; petiolar node placed near the petiolar-postpetiolar juncture; color usually pale yellow, or if dark, then the appendages are pale; subterranean (except for one rare yellow arboreal species). 2

2a) Head, thorax, and gaster dark brown with pale brown or pale yellow appendages; eyes of medium size for this group of species; with 2, occasionally 3 facets; subterranean. . . nickersoni n.sp.

b) Usually entirely pale yellow to somewhat darker yellow; one species (carolinensis) with moderate infuscations of brown on head and gaster. 3

3a) Dense pilosity on head and usually on promesonotum arising from large, obvious punctures; eyes small or weakly pigmented or both 4

b) Pilosity not arising from large, obvious punctures and not noticeably dense; eyes larger or at least pigmented, the facets surrounded by a black matrix 7

4a) Thorax in profile straight above; base and declivity of propodeum distinguishable; head narrow and elongate, head index 79; punctures on head over entire surface, no median streak free of punctures and hairs. . . . . . . *tennesseensis M. R. Smith

b) Head proportionately not as narrow; head in some species with distinct median streak free of punctures and hairs; propodeum usually evenly rounded in profile and without distinguishable base and declivity 5

5a) Head with obvious median streak free of punctures and hairs (Fig. 2), in mounted specimens a median crease may also be present in this area (but this is not evident in living or freshly killed specimens); head elongate and narrow, head index 89; females and males dark brown or black; head of female trapezoidal in shape . . . . abdita n.sp.

b) Without this combination of characters; head either without median hair-free streak, or head nearly as broad as long; head never with median crease in mounted specimens; males and females either light yellow or, if black, then head of female not trapezoidal in shape 6

6a) Large species 1.8 mm in total length with head 0.429 ± 0.009 mm in length; head index 96; head thick and robust in profile; shaped as in Fig. 18; males and females yellow or light brownish yellow; wings clear and nearly colorless. . . . . pergandei Forel

b) Small species 1.1 mm in total length; head 0.318 ± 0.002 mm in length, head index 77; head flattened above and slender in

profile; males and females dark brown to black; wings heavily and entirely infuscated with dark brown. . . . . xenovenenum n. sp.

7a) Dorsal surfaces of head with moderately numerous hairs nearly entirely of the same short length (Figs. 6, 26). 8

b) Dorsal surfaces with sparser hairs, these distinctly uneven in length (Fig. 10). 9

8a) Rear of head and anterior portion of gaster lightly to moderately infuscated with brown; eyes with 3 or 4 facets; females yellowish to light yellowish brown; female eyes very large, eye index 41 . . . . carolinensis Forel

b) Head and gaster without infuscation; uniformly pale yellow, some specimens nearly whitish; eyes with 2 facets; females dark brown to black; female eyes small, eye index 33. . . reinerti n.sp.

9a) Comparatively large size; body length 1.58 mm; head length 0.491 ± 0.004 mm; head and gaster usually weakly infuscated; subterranean . . . .*texana Emery

b) Small size, body length 1.34 mm; head length 0.363 ± 0.003 mm; entirely light brownish yellow without trace of infuscation on any areas; arboreal . . . . corticalis Forel

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*S. (D.) tennesseensis and S. (D.) texana were not found in Florida in the present study, and previous records seem doubtful. It is possible that these species will eventually be found in Florida.

1. Solenopsis (Diplorhoptrum) abdita n.sp.

Diagnosis:

Workers pale colored, and densely covered with short hairs. Head strongly marked with prominent punctures but with a clear median streak free of piligerous punctures. Eyes reduced to one facet, inconspicuous. Head broader in proportion to length than in tennesseensis, and thorax more convex in profile. Females large and dark colored, the head uniquely trapezoidal in shape. Wings colorless. Head and thorax with numerous piligerous punctures.

Description:

Worker:

Measurements: Head length 0.361 ± 0.004 mm; head width 0.32 ± 0.002 mm, head index 89, scape length 0.235 ± 0.003 mm, scape index 65. Thorax length 0.444 ± 0.003 mm, total body length 1.56 mm. The preceding measurements based on nine specimens.

Structural Characters: Head longer than wide, rectanguloid with faintly convex sides, the posterior border slightly excised in the center. In some specimens the head is slightly more narrow anteriorly. The eyes reduced to a single facet. Ventral border of head moderately convex in profile. Anterior edge of clypeus widely and angularly separated from dorsal surface of mandible in profile. A flat head (Fig. 25) not present.

Promesonotum of thorax weakly convex in profile, propodeal base somewhat more convex. Petiole large in profile with a

prominent anterioventral tooth and prominent ventral swelling (Fig. 27). From above, petiole and postpetiole nearly equal in width. Postpetiole with rounded sides as seen from above, not trapezoidal. Anterioventral flange of postpetiole seen in profile sharp but very small.

Sculpture: All surfaces smooth and shining except for head which is heavily and densely marked with prominent punctures and dorsum of the promesonotum which is moderately marked with weaker punctures. Head has characteristic median streak free of punctures.

Pilosity: Head with numerous short hairs. Thorax, petiole, postpetiole, legs, and gaster also with numerous short hairs which may be longer than those on the head (Fig. 1).

Color: Entirely light yellow to light yellowish brown.

Female:

Diagnosis: A rather large, dark colored female with colorless wings. Head distinctly trapezoidal in shape. Head and dorsum of thorax covered with numerous strong piligerous punctures. Differs markedly from S. (D.) pergandei females in color and head shape.

Description: Head length 0.78 mm, head width 0.98 mm, head index 126, scape length 0.67 mm, scape index 86, eye length 0.24 mm, body length 5.5 mm.

Structural Characters: Head distinctly trapezoidal, with nearly straight hind border and sides, the head distinctly more narrow in front than behind. Scapes not quite reaching hind

corners of the head. Eyes rather small for _Diplorhoptrum_ females. Ocelli also small for females of this group. Petiole with blunt node, slightly excised above as seen from behind. Postpetiole wider than petiole, trapezoidal as seen from above, wider posteriorly than anteriorly.

Pilosity: Head and thorax with numerous hairs arising from strong punctures. Gastric pilosity also abundant but not arising from punctures. A median streak on head free from punctures or hairs as in the worker.

Color: Head, thorax, petiole, postpetiole and gaster dark brown. Legs and antennae light greyish yellow. Wings colorless.

Male: Unknown

Types:

Holotype--a worker from Gainesville, Florida, captured with a Naves trap (June 16, 1979). Airport area. C. R. Thompson

Paratypes--numerous specimens from Gainesville Airport area, June through September, 1979, C. R. Thompson; three workers and one female from Tall Timbers Research Station, Florida. June, 1975. M. A. Naves.

The holotype and several paratypes will be deposited at the Museum of Comparative Zoology. Paratypes will also be deposited in the Florida State Collection of Arthropods, Gainesville, Florida.

Discussion:

This species appears superficially close to _pergandei_ on one hand and to _tennesseensis_ on the other. The female, dark in color and with

a unique head shape, shows that the species is not close to pergandei. The punctures on the head are stronger even than in pergandei, and the clear median streak on the head free of punctures seems to be a constant character which does not occur in tennesseensis. The head is narrower in proportion to length than in pergandei but is noticeably wider than in tennesseensis. The dorsum of the thorax is more flattened in tennesseensis than in abdita. Scape and funiculus length shorter in abdita than in pergandei.

This species has been found at Gainesville and Tall Timbers Research Station north of Tallahassee. It was relatively common in the test area near Gainesville although not as abundant as carolinensis. The species may not be rare, but merely previously overlooked and/or unrecognized.

2. Solenopsis (Diplorhoptrum) carolinensis Forel

Solenopsis texana race carolinensis Forel 1901. Ann. Soc. Entomol. Belg. 45:345.

Solenopsis (Diplorhoptrum) carolinensis Forel. Creighton, 1950. Bull. Mus. Comp. Zool. 104:236.

Type locality: Faisons, North Carolina

Types: Museum of Comparative Zoology, Harvard University

Range: North Carolina and Tennessee north to lower New England states

Diagnosis:

A small Diplorhoptrum with a quadrate-shaped head, moderately sized darkly pigmented eyes. Pilosity moderate, piligerous punctures weak. Pilosity on the head short and nearly all of the same length. In profile, often with an anterioventral tooth on the petiole. Head and gaster usually infuscated. Female small with large eyes.

Discussion:

Described as a characteristic species of North Carolina (Wheeler, 1904b) S. (D.) carolinensis is also a common species in Florida. It is very common in Gainesville, and was found wherever the Diplorhoptrum fauna was sampled throughout the state. It was found in many habitats: palmetto thickets, turkey oak, open sand areas, rocky soil in Homestead, grassy areas, and pine woods.

The nests of this species are shallow (less than 20 cm) and quite frequently one turn with a shovel will bring up the colony queen with a small group of brood and workers. A colony can have more than one queen. This species tends to forage more than most other Florida

species in the forest duff, and I have seen it tending mealy bugs.

Excavations of an S. (D.) pergandei colony will often bring S. (D.) carolinensis to light in the same shovelfull. The larvae of S. (D.) carolinensis have a pinkish cast and are smaller than those of S. (D.) pergandei.

The mating flights of this species have not been observed, but I have dug sexual brood in June (6/9/79) and the flights occur during the same months (June through August) as those of S. (D.) pergandei. The sexuals of S. (D.) carolinensis are attracted to light traps, but in smaller numbers than S. (D.) pergandei. The sexuals of S. (D.) carolinensis fly earlier in the morning (5-5:30 a.m.).

I suspect that the Florida S. (D.) molesta records, and one of S. (D.) laeviceps (Smith, 1930), are based on misidentified specimens of S. (D.) carolinensis. Types of this species at the Museum of Comparative Zoology have been examined by Dr. William F. Buren.

3. Solenopsis (Diplorhoptrum) corticalis Forel

Solenopsis corticalis Forel, 1904. Ann. Soc. Entomol. Belg. 48:172.

Type locality: Cuba

Types: Museum d' Histoire Naturelle, Geneva, Switzerland. None in this country

Range: West Indies (Wheeler, 1913; Wolcott, 1948) and southern Florida

Diagnosis:

Small arboreal species. Head is rectangular and the eyes are large in comparison with other species of the group. Petiole has anterioventral tooth. Hairs are rather sparse, of uneven lengths and do not arise from punctures. The integument is highly shining. Color is yellow or light brownish-yellow, usually without trace of infuscation.

Discussion:

This is one of the two known arboreal Diplorhoptrum in Florida, but appears to be much rarer than picta and is yellowish whereas picta is black to dark reddish-brown.

Prior to this study, S. (D.) corticalis had not been reported from Florida. A series of this species was taken near Manalapan, a coastal town south of Palm Beach in November, 1945, by Dr. William F. Buren. It was found in branches of red mangrove (Rhizophora mangle L.). It was subsequently rediscovered by Dr. J. C. Nickerson in the same habitat in May, 1980, on Park Key. This species is polygynous and is probably nocturnal, as no foragers were seen in the daylight. Specimens from the Manalapan series have been compared with West Indian material at the Museum of Comparative Zoology by Dr. William F. Buren.

4. Solenopsis (Diplorhoptrum) molesta (Say)

Myrmica molesta Say, 1836. Boston J. Natur. Hist. 1:293.

Myrmica minuta Say, 1836. Boston J. Natur. Hist. 1:293.

Myrmica (Tetmamorium) exigua Buckley, 1867. Proc. Entomol. Soc. Philadelphia 6:342-3.

Solenopsis debilis Mayr, 1886. Zool.-Bot. Gesell. Wien, Verh. 36:461.

Solenopsis molesta var. validiuscula Emery, 1895. Zool. Jahrb., Abt. f. System. 8:278.

Solenopsis (Diplorhoptrum) molesta (Say), Creighton, 1950. Bull. Mus. Comp. Zool. 104:237.

Type locality: Indiana

Types: No longer in existence

Range: Reported from east and central U.S. from the Gulf States to Canada. Supposedly rare in the southern areas of the Gulf States.

Diagnosis:

Head and thorax robust, broad in relation to length. In profile the petiole considerably larger than the postpetiole, but seen from above the postpetiole much wider than the petiole. Differs from carolinensis and texana in having a distinctly broader thorax. Hairs are sparse and of mixed lengths. No obvious piligerous punctures.

Discussion:

It is this species name which has been most abused in the literature. Authors are legion (Browne and Gregg, 1969; Mann, 1911; Robbins, 1910; Rees and Grundmann, 1940; Talbot, 1975; Yensen and Clark, 1977) who list this ant, but give little or no additional information. For

Florida, _S_. (_D_.) _molesta_ is reported from Rockdale, in Dade County, (Nielsson et al., 1971) where it was tending _Aphis coreopsidis_ (Thomas), but no further information on the biology is given. Van Pelt (1958) reports this species from Welaka Reserve and observed the ants closely. He noted that what he was tentatively calling _molesta_ did not match specimens he had seen. Van Pelt was one of the few authors (Mitchell and Pierce, 1912; Ross et al., 1971; Huddleston and Fluker, 1968 were others) who qualified their identifications and noted the existing taxonomic confusion.

At this time I have found no specimens of _S_. (_D_.) _molesta_ in Florida, nor have I seen any in other Florida collections. Van Pelt's specimens are _S_. (_D_.) _carolinensis_.

5. Solenopsis (Diplorhoptrum) nickersoni n.sp.

Diagnosis:

A small dark species similar to S. (D.) carolinensis in head shape, eye characteristics, thorax, and petiole shape. Antennae and legs pale-colored and strongly contrasting with body color.

Description:

Worker:

Measurements: Head length 0.345 ± 0.003 mm, head width 0.30 ± 0.002 mm, head index 86, scape length 0.241 ± 0.003, scape index 70, funiculus length 0.359 ± 0.004 mm, club length 0.222 ± 0.002 mm. Thorax length 0.384 ± 0.004 mm, body length 1.2 mm. The preceding measurements based on 18 specimens.

Structural characters: Head longer than broad (Fig. 14), rectanguloid, with weakly convex sides and straight posterior border. Head in profile with a narrow angle between the clypeus and mandibles. Head in profile moderately flattened. Eyes dark in color with 2-3 facets, similar to carolinensis.

Thorax in profile (Fig. 13) with moderate meso-propodeal suture, the dorsal outline similar to carolinensis. Petiole in profile similar to carolinensis (Fig. 7). Petiole usually without anterioventral teeth. From above, node of petiole a little narrower than postpetiole. Postpetiole with trapezoidal shape as in carolinensis. In profile postpetiole with sharp anterioventral flange (Fig. 15).

Sculpture: All surfaces smooth and shining. Piligerous punctures on dorsum of head weak and not noticeably interrupting the surface.

Pilosity: Head with rather short, sparse hairs. Thorax with longer hairs in moderate numbers. Gaster also moderately beset with hairs.

Color: The head, thorax, petiole, postpetiole, and gaster dark brown; antennae and legs, including coxae, very pale brown, almost whitish.

Female: Unknown?

Male: Unknown?

The purported females and males of nickersoni thus far have not been found with workers. A match was made by a process of elimination. All other dark colored females and males occurring in Florida have been found with conspecific workers. The dark bodies of nickersoni contrasting with the pale colored appendages is a characteristic found in both the workers and the purported females and males, but descriptions await a collection of sexuals with workers.

Types:

Holotype--a worker from Gainesville, Florida, caught in a Naves trap on June 16, 1979. Paratype material comprises numerous workers collected in Gainesville, Ocala, and Apopka, Florida on various dates with Naves traps. All were collected by C. R. Thompson.

The holotype and several paratypes will be deposited at the Museum of Comparative Zoology. Paratypes will also be deposited in the Florida State Collection of Arthropods, Gainesville, Florida.

This species is named in honor of Dr. J. C. Nickerson, Division of Plant Industry, Gainesville, Florida. Dr. Nickerson, over a period of several years, has greatly aided and encouraged me in my myrmecological studies.

Discussion:

S. (D.) nickersoni is readily distinguished from all other Florida ants of this genus by its dark color which contrasts with the light color of its antennae and legs. In structure it is similar to carolinensis including head shape, eye prominence, thoracic shape, and petiole and postpetiole shape. It lacks the prominent head punctures which are typical of pergandei, abdita, and xenovenenum n.sp.

This species has been found in Florida at Gainesville, Ocala, Apopka and Myakka State Park. The species, from data collected in 1979 at Gainesville, appeared to be rare. It was caught in only one area and in one trap position out of 100. In 1980, however, it has been taken in April and June at nine trap locations in both open field and wooded areas.

The venom of this species has not been analyzed.

In two instances, workers of nickersoni were attracted to a second (or third) larval instar of Diaprepes abbreviatus (L.), the Sugar Cane Rootstalk Borer, in a Naves trap, and were able to kill and dismember the weevil larva. This occurred on May 13 and June 9, 1980, near Plymouth, Florida, in a wooded area probably relatively free from

insecticides. *S*. (*D*.) *nickersoni* was not found in any citrus grove area near Apopka or Orlando which had been treated by insecticides or herbicides.

6. Solenopsis (Diplorhoptrum) pergandei Forel

Solenopsis pergandei Forel, 1901. Ann. Soc. Entomol. Belg. 45:343.

Solenopsis (Diplorhoptrum) pergandei Forel. M. E. Smith, 1947. Amer. Mid. Natur. 37:568.

Solenopsis (Diplorhoptrum) pergandei Forel. Creighton, 1950. Bull. Mus. Comp. Zool. 104:237.

Type locality: Faisons, North Carolina.

Types: Museum d' Histoire Naturelle, Geneva, Switzerland. None in this country

Range: Virginia and south to Florida, west to Louisiana.

Diagnosis:

This clear-yellow Diplorhoptrum is the largest species of this subgenus in Florida. The worker is approximately 1.8 mm long while the large females are 5.5 mm long. It also differs from other Florida species in its robust head and thorax. Piligerous punctures on head numerous and distinct. Head quadrate, only a little longer than broad, convex dorso-ventrally in profile.

Discussion:

This species is common in Florida, and was found over the entire state. It does not leave any surface indication of its nests except during May through August in Florida when it constructs crenelated tumuli the night before a mating flight (see Section 2).

This ant prefers to nest in areas which are quite dry and where the soil is compacted such as lawns and woods trails. I have found it in large numbers under a baseball diamond in full midday sun. In

Mississippi, it was nesting in soil and rotting stumps (Smith, 1931). In Florida, Smith (1944) found it constructed small crater nests in semiboggy ground near scrub and in loam beneath moss or pine needles. Van Pelt (1958) found it in quite well-drained areas. Whitcomb et al. (1972) found that it built flat honeycombed mounds about 1 foot deep in canefields. He observed that the species seemed to be thriving and was strictly nocturnal. The Whitcomb et al. observations seem questionable for S. (D.) pergandei and may be based upon a misdetermination.

7. Solenopsis (Diplorhoptrum) picta Emery

Solenopsis tenuis Mayr, 1886. Zool-Bot. Gesell. Wien, Verh. 36:262. Nec. S. tenuis Mayr 1877.

Solenopsis picta Emery, 1895. Zool Jahrb., Abt. f. System. 8:278.

Solenopsis picta var. moerens Wheeler, 1915. Bull. Amer. Mus. Natur. Hist. 34:393.

Solenopsis (Diplorhoptrum) picta. Creighton 1950. Bull. Mus. Comp. Zool. 104:237-238.

Type locality: Florida

Types: Museo Civico di Storia Naturale "Giacomo Doria," Genoa, Italy

Range: Gulf States from Florida west to Texas

Diagnosis:

An arboreal species living in tree twigs. It has a strong mesopropodeal impression, and the promesonotum and propodeum are both strongly convex in profile. Petiolar node set forward from the petiolar-postpetiolar juncture. Hairs are sparse, and of various lengths, and do not arise from punctures. The body shining. Color black, including appendages. A color variant occurs which is paler, often reddish brown.

Discussion:

This species is common throughout Florida and the southeastern states, but is limited to habitats with dead wood and twigs in which to nest. It is a polygynous species, easily reared in the laboratory. I have a colony captured two years ago, July 23, 1978, which produced sexuals this past May. The sexuals are not attracted to light traps. Van Pelt found this species most commonly in bayhead areas (1958).

8. Solenopsis (Diplorhoptrum) reinerti n.sp.

Diagnosis:

A small pale species. Eyes small but darkly pigmented. General characters of workers similar to carolinensis, but queens dark in color except for pale appendages, with small eyes and ocelli.

Description:

Worker:

Measurements: Head length 0.336 ± 0.003 mm, head width 0.285 ± 0.003 mm, head index 85, scape length 0.225 ± 0.003 mm, scape index 67, funiculus length 0.332 ± 0.006 mm, club length 0.207 ± 0.004 mm. Thorax length 0.359 ± 0.004 mm, body length 1.58 mm. The following measurements based on 12 specimens.

Structural characters: Head quadrate, longer than broad with weakly convex sides and straight posterior border. Eyes small but pigmented, with two or three facets. Mandibles with four teeth.

Thorax similar in structure to carolinensis. Propodeum smoothly rounded in profile without definite base or declivity. Petiole similar in shape to that of carolinensis but without ventral concavity and the anterioventral teeth characteristic of carolinensis (Fig. 27). Postpetiole a little wider than petiole seen from above and weakly trapezoidal as in carolinensis. Postpetiole shorter in proportion to length than in carolinensis.

Sculpture: Head with noticeable but small punctures, these much weaker than in pergandei, tennesseensis, abdita, or xenovenenum n.sp. Remainder of integument smooth and shining.

Pilosity: Head with numerous short hairs, thorax with less numerous, somewhat longer hairs.

Color: Pale yellow or very pale brown, the integument largely transparent.

Female:

Measurements: Head length 0.54 mm, head width 0.54 ±0.002 mm, head index 100, scape length 0.40 mm, funiculus length 0.52 mm, scape index 74, body length 2.7 mm.

Structural characters: Head as long as broad with convex sides and straight or very slightly concave posterior border. Clypeal teeth weak. Mandibles each with four teeth. Eyes and ocelli small.

Thorax distinctly narrower than the head. Petiole with a high node, and without anterioventral teeth. Postpetiole with anterioventral flange. Wider than petiole as seen from above and weakly trapezoidal.

Sculpture: Head with numerous well marked punctures. These are weaker but noticeable on the thorax.

Pilosity: All surfaces with numerous hairs of moderate length.

Color: Head, thorax, petiole, postpetiole, and gaster dark brown. Mandibles, scapes, funiculi, and legs pale yellow or pale brown.

Male: Unknown

Types:

Holotype a worker taken by core sod sampling in Dade County, Florida, on July 29, 1974, by J. A. Reinert. Paratypes are numerous workers and females collected by J. A. Reinert. Other paratypes are one female (and workers later reared by her) collected on June 23, 1979, in Gainesville, Florida, by C. R. Thompson.

The holotype and several paratypes will be deposited at the Museum of Comparative Zoology. Paratypes will also be deposited in the Florida State Collection of Arthropods, Gainesville, Florida.

This species is named in honor of J. A. Reinert who was the first to capture this cryptic new species.

Discussion:

Very little is known about this new species. J. C. Trager (Department of Entomology and Nematology, University of Florida) found sexuals and workers of this species beneath a stone at the edge of woods on June 29, 1980. He collected *reinerti* males at a blacklight at 5:45 a.m. on June 26, 1980.

The workers of this species are so similar to those of *carolinensis* that identifications remain questionable if only workers are available. The dark brown to black female, however, is so different from the large-eyed, reddish-yellow female of *carolinensis* that it is clear that two taxa are involved. Although presently known from only two Florida localities, the species may prove to be common and widespread.

9. Solenopsis (Diplorhoptrum) tennesseensis M. R. Smith

Solenopsis (Diplorhoptrum) longiceps M. R. Smith, 1942. Proc. Entomol. Soc. Wash. 44:210. Preoccupied by Forel, 1907.

Solenopsis (Diplorhoptrum) longiceps M. R. Smith. Creighton, 1950. Bull. Mus. Comp. Zool. 104:236-236.

Solenopsis (Diplorhoptrum) tennesseensis M. R. Smith, 1951. In Muesebeck, U.S.D.A. Agr. Monog. 2:814. N. name.

Type locality: Hamilton Co., Tennessee.

Types: United States National Museum, Washington, D. C.

Range: Florida west to Texas and north to latitude of Tennessee.

Diagnosis:

We did not find this subterranean species in Florida in spite of previous records. It has probably been confounded with the new species S. (D.) xenovenenum. S. (D.) tennesseensis is unusual in having a slender head. The thorax in profile is straight dorsally and the propodeum has a distinct base and declivity. Head and thorax with numerous short hairs arising from distinct punctures. It differs from S. (D.) abdita in not having a clear median streak free from punctures and hairs on the head.

Discussion:

This study has shed no new light on the biology or distribution of S. (D.) tennesseensis. Little information is present in the literature. This species is known primarily from the type series. The range given by Creighton (1950) may not be accurate.

10. _Solenopsis_ (_Diplorhoptrum_) _texana_ Emery

Solenopsis pollux var. _texana_ Emery, 1895. Zool Jahrb., Abt. f. System. 8:278.

Solenopsis texana Forel, 1901. Ann. Soc. Entomol. Belg. 45:345.

Solenopsis rosella Kennedy, 1938. Can. Entomol. 70:232.

Solenopsis (Diplorhoptrum) texana Creighton, 1950. Bull. Mus. Comp. Zool. 104:238.

Type locality: Texas

Types: Museo Civico di Storia Naturale "Giacomo Doria", Genoa, Italy. A questionable series is at the Museum of Comparative Zoology at Harvard.

Range: Central Texas and southeastern states north to Canada

Diagnosis:

Similar to _molesta_, but head more slender, thorax distinctly more slender. Postpetiole a little wider than the petiole seen from above. Hairs sparse and of mixed lengths. No piligerous punctures. Head and gaster often weakly infuscated.

_S_. (_D_.) _texana_ is larger than _carolinensis_ and the hair patterns are different. The small females with the very large eyes seem to be unique to _carolinensis_.

Discussion:

I have not been able to find this species in Florida. Although Krombein et al. (1971) list this species from Florida, I suspect examination of the specimens would show them to be _carolinensis_. Authentic specimens of _S_. (_D_.) _texana_ may eventually be found in the state.

11. Solenopsis (Diplorhoptrum) truncorum Forel

Solenopsis texana race truncorum Forel, 1901. Ann. Soc. Entomol. Belg. 45:346.

Solenopsis molesta var. castanea Wheeler, 1908. Bull. Amer. Mus. Natur. Hist., 24:430.

Solenopsis (Diplorhoptrum) truncorum Creighton, 1950. Bull. Mus. Comp. Zool. 104:239.

Type locality: Faisons, North Carolina

Types: Museum d'Histoire Naturelle, Geneva, Switzerland.

Range: Southeastern U.S. and west to the Rocky Mountains.

Diagnosis:

A large, dark-colored species with rather sparse scattered hairs of mixed lengths. This species is common in the mountains of the western U.S., but also occurs in the eastern Appalachian Mountains.

Discussion:

The large dark brown castanea was synonymized under truncorum by Creighton (1950). No types of truncorum are present in this country, but the types of castanea were compared with various Florida species by Dr. William F. Buren. The Florida specimens did not match the types of castanea.

I have not found this species in Florida, although Smith (1979) lists the species as occurring in this state.

12. *Solenopsis* (*Diplorhoptrum*) *xenovenenum* n.sp.

Solenopsis tennesseensis Krombein, Hurd, Smith, Burks. Catalog of Hymenoptera in America North of Mexico. Smithsonian Institution Press, Washington, D.C. 1979. p. 1388. *in part*, *nec* M. R. Smith

Diagnosis:

Very small yellow species. Head with prominent punctures, pilosity short and numerous on all surfaces. Head elongate as in *tennesseensis*. Eyes reduced to a single facet. Males and females with characteristic darkly infuscated wings.

Description:

Worker:

Measurements: Head length 0.317 ± 0.002 mm, head width 0.245 ± 0.002 mm, head index 77, scape length 0.191 ± 0.002, scape index 60, funiculus length 0.296 ± 0.003 mm, club length 0.191 ± 0.002 mm. Thorax length 0.336 ± 0.004 mm, body length 1.1 mm. The preceding measurements based on 18 specimens.

Structural characters: Head (Fig. 30) distinctly longer than broad with weakly convex sides and straight or slightly excised posterior border. Antennal scapes reaching 2/3 the distance from insertions to hind corners of head. Eye reduced to one facet, usually pigmented. In profile head somewhat flattened dorsally, slightly convex ventrally. Anterior edge of clypeus angularly separated from dorsal surface of mandibles seen in profile.

Thorax weakly convex; propodeum rounded without definite base or declivity (Fig. 29). Petiole without anterioventral tooth. From above the petiole and postpetiole are about the same width. Postpetiole with rounded sides.

Sculpture: Dorsum of head covered with distinct punctures but these not as strong as in tennesseensis or abdita. Dorsum of promesonotum also with some weak punctures. All other surfaces smooth and shining.

Pilosity: Hairs short and numerous on all surfaces. There may be some longer hairs on the thorax, gaster, and petiole.

Color: Yellow to pale yellowish brown.

Female:

Measurements: Head length 0.59 mm, head width 0.64 mm, head index 108 mm, scape length 0.46 mm, scape index 78, funiculus length 0.60 mm, total body length 3.24 mm.

Structural characters: Head quadrate, a little longer than broad with both sides and occipital border nearly straight or only slightly convex. Scapes nearly reaching hind corners of the head. Ocelli rather small, measuring 0.02 mm in diameter and separated from each other by at least one diameter.

Thorax slightly narrower than head. Petiole without anterioventral tooth. Node of petiole with slightly excised superior border seen from behind. Petiole and postpetiole of the same width. Postpetiole weakly trapezoidal as seen from above, wider posteriorly than anteriorly.

Sculpture: Head with scattered moderate punctures; mesonotum with weak punctures. Pleurae of propodeum, petiole, and postpetiole weakly striate or shagreened. All other surfaces smooth and shining.

Pilosity: Body and appendages with numerous short hairs. Wings with dark brown veins and stigma, membranes also completely infuscated with brown.

Color: Entire body including appendages brownish to dark brown.

Male:

Measurements: Head length 0.40 mm, head width (including eyes) 0.50 mm, thorax length 1.08 mm, petiole length 0.34 mm, eye length 0.19 mm, body length 2.82 mm.

Structural characters: Antennae 12-jointed, last two joints and particularly the last joint longer than other funicular joints, but not enlarged or clublike. Eyes occupying about one-half of head length, ocelli 0.065 mm in diameter. Mandibles weak, each with 2 or 3 teeth. Head trapezoidal in shape.

Thorax without Mayrian furrows on the mesonotum. Petiolar node with slightly concave superior border.

Sculpture: Head and dorsum of thorax with weak punctures. Propodeum sculptured with striato-punctate markings. Petiolar node punctate.

Pilosity: All surfaces with numerous short hairs.

Color: Dark brown, including the appendages. Wing veins and membranes completely infuscated with brown.

Types:

Holotype--a worker collected by Naves trap on June 16, 1979, by C. R. Thompson. Paratypes are numerous workers taken in Naves traps June to October, 1979.

The holotype and several paratypes will be deposited at the Museum of Comparative Zoology. Paratypes will also be deposited in the Florida State Collection of Arthropods, Gainesville, Florida.

Discussion:

This species is so named because it was found by Dr. Tappey Jones (Univ. of Georgia) to have (5Z,8E)-3-heptyl-5-methyl pyrrolizidine as the main constituent of its venom. This compound is new to biology. The species is common throughout the state in many habitats.

Males and females have been observed in an afternoon flight at Homestead, Florida, in July, 1964. Males have been taken from a spider web in Gainesville, Florida, on July 30, 1978, and from a light trap in Miami Beach (June 3, 1947). This is the smallest *Diplorhoptrum* species in the United States and has been taken from under stones, unlike most other species of the subgenus in Florida.

PLATE 1

Figure 1. Lateral view of worker of S. (D.) abdita n. sp. (65X)

Figure 2. Head of the worker of S. (D.) abdita n. sp. (120X)

Figure 3. Petiole and postpetiole of worker of S. (D.) abdita n. sp. (340X)

Figure 4. Dorsal view of worker of S. (D.) abdita n. sp. (50X)

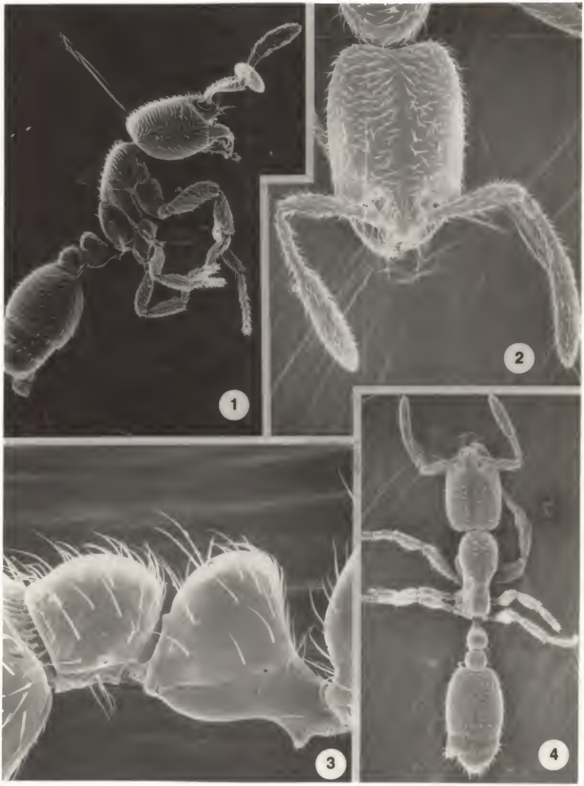

PLATE 2

Figure 5. Lateral view of worker of S. (D.) *carolinensis* Forel (60X)

Figure 6. Head of the worker of S. (D.) *carolinensis* Forel (130X)

Figure 7. Petiole and postpetiole of worker of S. (D.) *carolinensis* Forel (290X)

Figure 8. Dorsal view of worker of S. (D.) *carolinensis* Forel (56X)


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PLATE 3

Figure 9. Lateral view of worker of S. (D.) corticalis Forel (90X)

Figure 10. Head of the worker of S. (D.) corticalis Forel (200X)

Figure 11. Petiole and postpetiole of worker of S. (D.) corticalis Forel (360X)

Figure 12. Dorsal view of worker of S. (D.) corticalis Forel (65X)

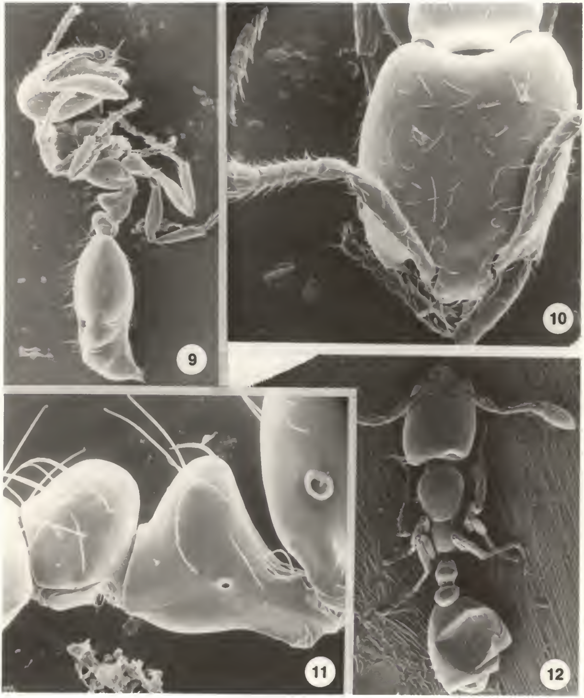

PLATE 4

Figure 13. Lateral view of worker of S. (D.) nickersoni n. sp. (75X)

Figure 14. Head of the worker of S. (D.) nickersoni n. sp. (120X)

Figure 15. Petiole and postpetiole of worker of S. (D.) nickersoni n. sp. (420X)

Figure 16. Dorsal view of worker of S. (D.) nickersoni n. sp. (65X)

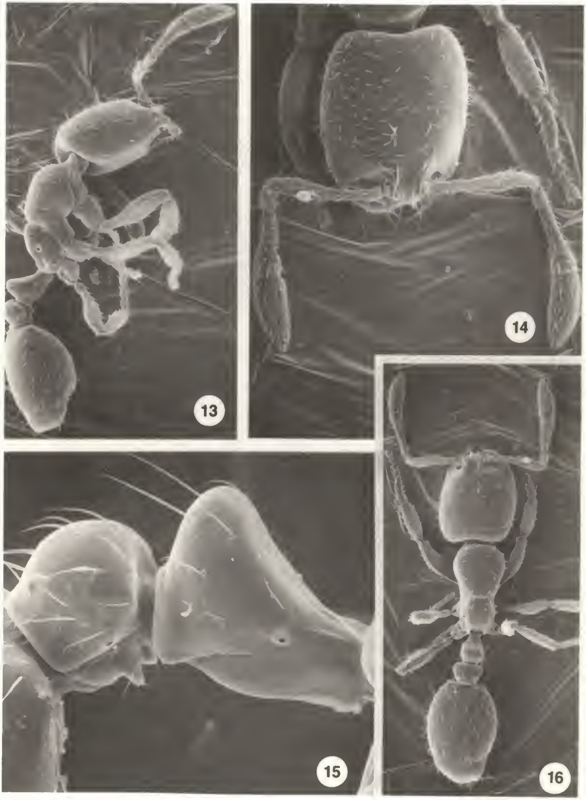
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PLATE 5

Figure 17. Lateral view of worker of S. (D.) pergandei Forel (79X)

Figure 18. Head of the worker of S. (D.) pergandei Forel (98X)

Figure 19. Petiole and postpetiole of worker of S. (D.) pergandei Forel (165X)

Figure 20. Dorsal view of worker of S. (D.) pergandei Forel (75X)


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PLATE 6

Figure 21. Lateral view of worker of S. (D.) *picta* Emery (70X)

Figure 22. Head of the worker of S. (D.) *picta* Emery (140X)

Figure 23. Petiole and postpetiole of worker of S. (D.) *picta* Emery (378X)

Figure 24. Dorsal view of worker of S. (D.) *picta* Emery (70X)

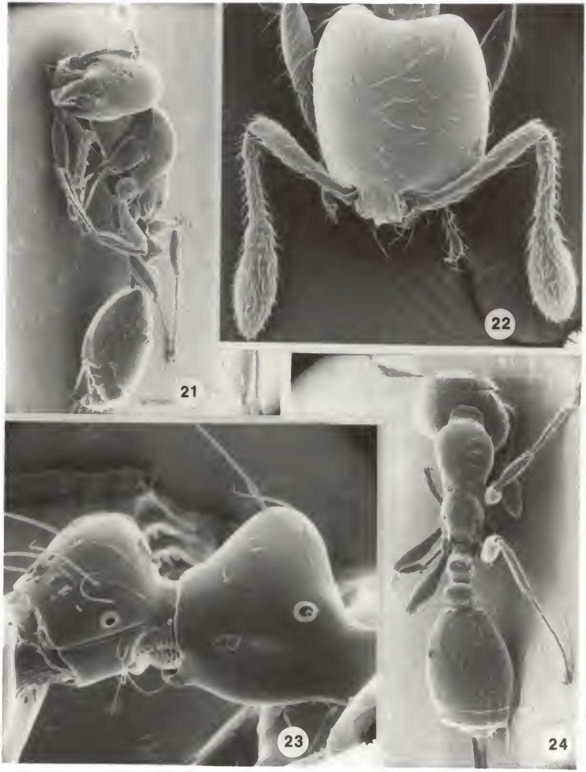
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PLATE 7

Figure 25. Lateral view of worker of S. (D.) reinerti n. sp. (90X)

Figure 26. Head of the worker os S. (D.) reinerti n. sp. (140X)

Figure 27. Petiole and postpetiole of worker of S. (D.) reinerti n. sp. (460X)

Figure 28. Dorsal view of worker of S. (D.) reinerti n. sp. (50X)

PLATE 8

Figure 29. Lateral view of worker of S. (D.) xenovenenum n. sp. (83X)

Figure 30. Head of the worker of S. (D.) xenovenenum n. sp. (150X)

Figure 31. Petiole and postpetiole of worker of S. (D.) xenovenenum n. sp. (460X)

Figure 32. Dorsal view of worker of S. (D.) xenovenenum n. sp. (84X)


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PLATE 9

Figure 33. Cluster of mating flight tumuli of S. (D.) *pergandei* Forel

Figure 34. Mating flight tumulus of S. (D.) *pergandei* Forel

Figure 35. Mating flight tumulus of S. (D.) *pergandei* Forel

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Section II
Subterranean Distribution of Diplorhoptrum Species

Mosaic distribution of ant species is well documented in cacao plantations (Majer, 1972; Leston, 1973), but these studies involved arboreal species in easily sampled ecological niches, i.e., cocoa trees. Nothing was known of the distribution of Diplorhoptrum species below ground, particularly as no surface structures are constructed by these ants, with the exception of S. (D.) pergandei mating flight tumuli.

Accordingly, 5 x 10 meter grids were set up, and experimental trapping was begun in June, 1979. The results were immediate and surprising. Of 100 traps put down June 17, in 24 hours 59 were positive for ants and, of these, 43 contained Diplorhoptrum. Diplorhoptrum were captured in as many as 75 per cent of the traps during July and August and as few as 3 per cent in January. Some traps contained over 300 ants. An example of the results is shown in Fig. 36 for the longleaf pine-turkey oak woods. Five species of Diplorhoptrum were captured in the traps during this study. All were present in the first set of traps put down on June 17. Numbers of traps in which each Diplorhoptrum species was captured throughout the year are presented in Figs. 37 and 38.

It is evident that S. (D.) carolinensis was the dominant subterranean ant in both habitats. S. (D.) pergandei was absent from the field habitat, and present at only two trap locations in the woods grid. S. (D.) xenovenenum also had a distinct pattern in that they were captured in only 2 traps in the field, but were evenly distributed in the wood.

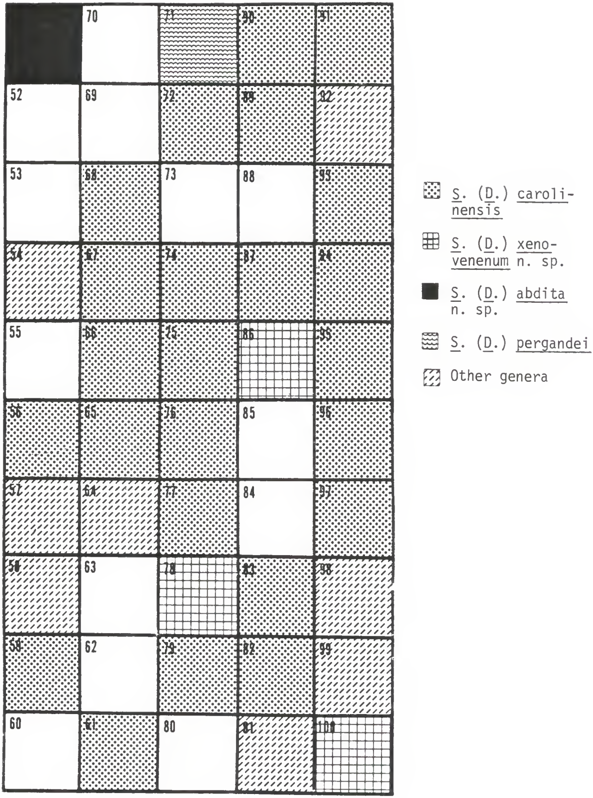

Figure 36. Example of Naves trap samples of Diplorhoptrum and other species distribution in a long leaf pine-turkey oak woods on June 24, 1979, at Gainesville, Florida.

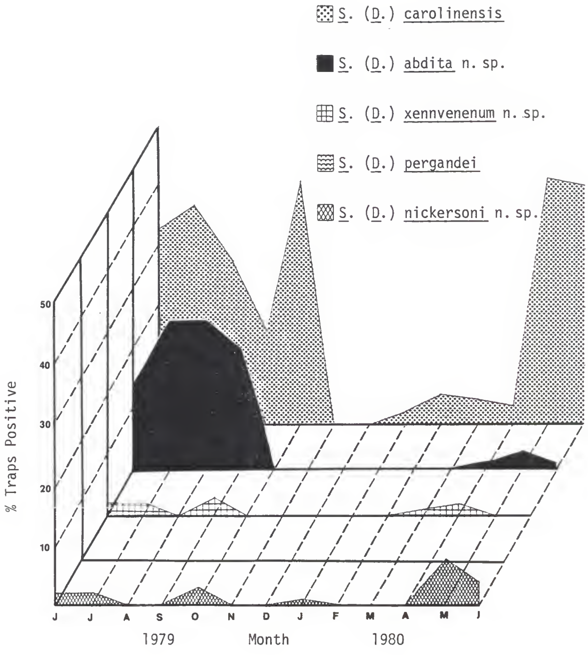

Figure 37. Diplorhoptrum species captured by Naves trap in an open field at Gainesville, Florida, from June 1979-June 1980.

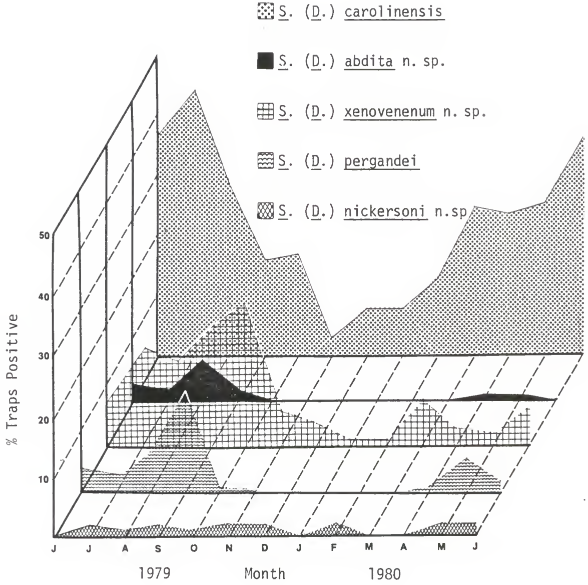

Figure 38. Diplorhoptrum species captured by Naves trap in a long leaf pine-turkey oak woods at Gainesville, Florida, from June 1979-1980.

Ant activity dropped sharply between October and November and began to increase the following year between April and May. Having observed the sharp cessation of activity in the fall, I suspected soil temperatures might be a factor and began to monitor them. On April 15 the field soil temperatures taken at 14 cm were 15.3, 16.3 and 17.0° C. The wood soil temperatures were 16.0, 16.3 and 17.0° C. By May 16 a distinct increase was evident: field soil temperatures were 23.3, 23.3 and 24.0° C while wood soil temperatures were 21.0, 21.5 and 21.5° C. These data indicate that soil temperature may be a major factor in seasonal Diplorhoptrum activity patterns.

The major question posed by these collection data is how many nests and of what species are present? Estimates of colony numbers and territorial sizes can be made based on the following assumptions:

1. Few ant species build one-chambered nests, and all known Solenopsis build multi-chambered nests. It can be assumed Diplorhoptrum have multi-chambered nests.

2. All known Solenopsis have discrete nests. Large populations covering large areas without discrete nests probably do not occur in Diplorhoptrum species. Diplorhoptrum are here assumed to have discrete nests and foraging areas which do not extensively overlap.

3. From the appearance of S. (D.) pergandei tumuli clusters, which are constructed following rain (Fig. 33), the network of chambers and tunnels below may be assumed to be diffuse. The nest probably occupies a region comparable to the size of the cluster on the surface and not more than 1 or 2 meters in area.

4. Each ant colony controls available food sources over as wide an area as possible. Dominant species may be assumed to control large

areas; subdominants to control proportionately smaller areas.

5. Whether dominant or subdominant, the closer a food source is to a nest, the more likely that colony will be able to successfully exploit and control the food source.

6. Subdominants or non-dominants probably can not maintain complete control over foraging areas unless near their nests. Specific traps (i.e., Meter 8 with S. (D.) nickersoni or Meters 70 and 71 (Fig. 37) with S. (D.) pergandei) were nearly always positive with certain subdominants, therefore it is probable that these traps were located near a nest of the subdominant, and that a single colony of the subdominant is indicated by each of these locations.

7. It can be assumed that any trap location in which one species was consistently collected and which was nearly always positive is likely to be close to the nest location of a dominant.

Therefore the nest of each subdominant, and the nest areas of each dominant should be countable with reasonable accuracy. With these assumptions, and the summation method of assembling the data, the nesting pattern and general foraging areas of the various species sampled can be estimated. Data were summed by counting the numbers of traps positive for each species, then multiplying each number by the percentage of the time a trap was positive for that species. For example, S. (D.) carolinensis was present, in Trap 12, 5 out of 7 or 77.7% of the times that the trap was positive with Diplorhoptrum. Multiplying 5 x 77.7% gives an experimental summation number of 544. The summation numbers were then arbitrarily divided into four groups and assigned to a pattern series, as shown in Figs. 39-43. From these patterns, rough estimates of the shape of foraging areas for each individual nest can be drawn.

S. (D.) carolinensis mosaic patterns were the most complex. In the field there appear to be four colonies with wide-ranging territories (Fig. 39). Foraging areas of two additional colonies appear to be only partially present in the grid. In the woods site, there is probably one large colony and a second smaller colony with a much smaller foraging area around Meter 82 (Fig. 41).

The colony and foraging patterns of S. (D.) abdita and S. (D.) xenovenenum are less complex. There appear to be 4 colonies of S. (D.) abdita in the field grid and only probably two colonies in the woods, with perhaps an incipient colony in Meters 84-85 (Figs. 40,42). S. (D.) xenovenenum occupied only one meter in the field site, but appeared to have three colonies (Fig. 43) and part of the foraging territory of a fourth in the woods site.

The data in Figs. 39-43 are subject to more than one interpretation and boundaries could easily be drawn somewhat differently. In addition, the true correlation of colony numbers and territories indicated by trapping data with those actually present in the field remains unknown. It is hoped that the Naves trap method may eventually be found to indicate true Diplorhoptrum territories and colony numbers.

In the field site S. (D.) carolinensis is the dominant species while S. (D.) pergandei is an occasional dominant, or to use Majer's (1972) terminology sensu strictu, a sub-dominant, i.e., a species capable at times of becoming a dominant. Yet many more S. (D.) pergandei queens were found during field excavation and in light traps than were S. (D.) carolinensis. This would be consistent with a species which does not expend energy in large queens and mating flights, but whose small queens may mate mostly in the nest and remain in the nest to produce large,

diffuse colonies. Dr. J. C. Nickerson collected a colony of *S.* (*D.*) *carolinensis* which had 6 queens. In the laboratory a number of *S.* (*D.*) *carolinensis* queens will found a nest together amicably, and will remain together without fighting after workers are reared. These data support the low energy--small queens hypothesis.

A second method of data analysis undertaken was a breakdown of positive trap counts by month of the year as shown in Figs. 44 and 45. Concentrations and suspected nest locations generally coincided with those obtained from the summation method. Comparisons must be made with caution, however, as data presented in Figs. 44 and 45 cover a year while Figs. 39-43 include data from a five month period.

The greatest weight was placed on the five month summation study results, after the tremendous fluctuations in species location data were noted. Fluctuation in colony locations was greatest following the relative inactivity of the winter months. Twenty traps remained positive for the same *Diplorhoptrum* species over the entire year. Intramonthly repeatability (June to Oct.) was high: 90% + 2.0, while intermonthly repeatability was substantial: 63% + 3.0. The number of traps common to the same species on June 17, 1979 and June 18, 1980 (first and last experimental dates) was eight, while the number of corresponding traps with different species was 11 and the remaining traps were positive on only one day or not at all.

In addition to the summation and by-month analyses of *Diplorhoptrum* distribution, a third method was proposed based on the following observations and hypothesis: during November through February, *Diplorhoptrum* activity was low, with *S.* (*D.*) *pergandei* and *S.* (*D.*) *abdita* activity ceasing entirely. If one makes the assumption

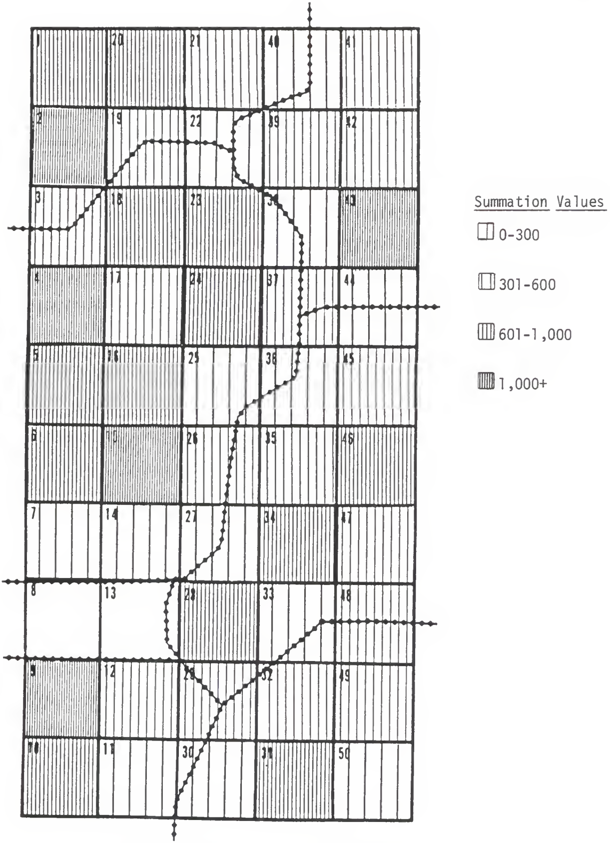

Figure 39. Five month (June-Oct., 1979) summation of the distribution by trapping of S. (D.) carolinensis in an open field at Gainesville, Florida.

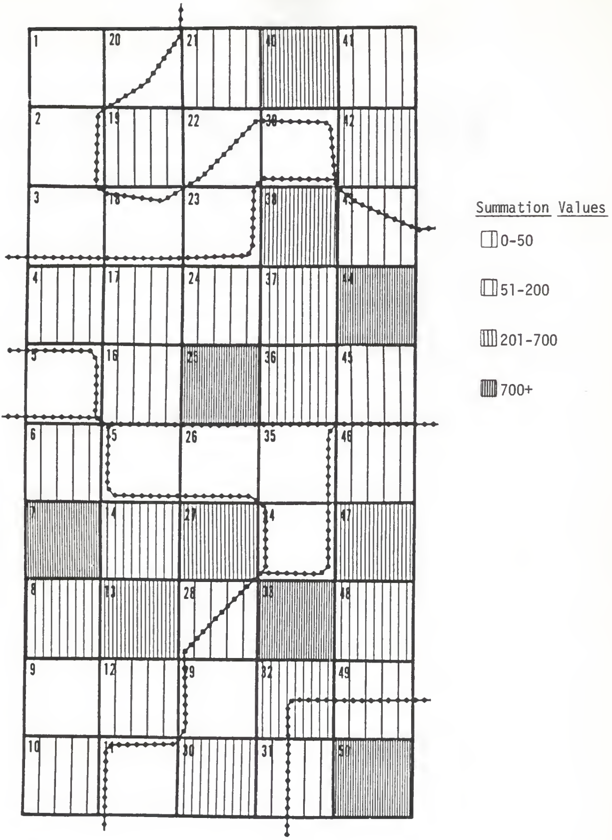

Figure 40. Five month (June-Oct., 1979) summation of the distribution by trapping of S. (D.) *abdita* in an open field at Gainesville, Florida.

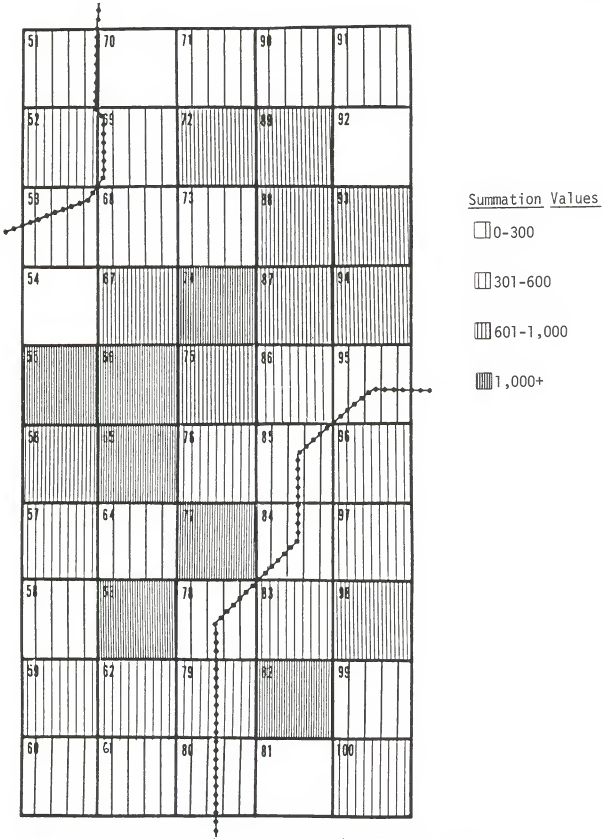

Figure 41. Five month (June-Oct., 1979) summation of the distribution by trapping of S. (D.) carolinensis in a long leaf pine-turkey oak woods at Gainesville, Florida.

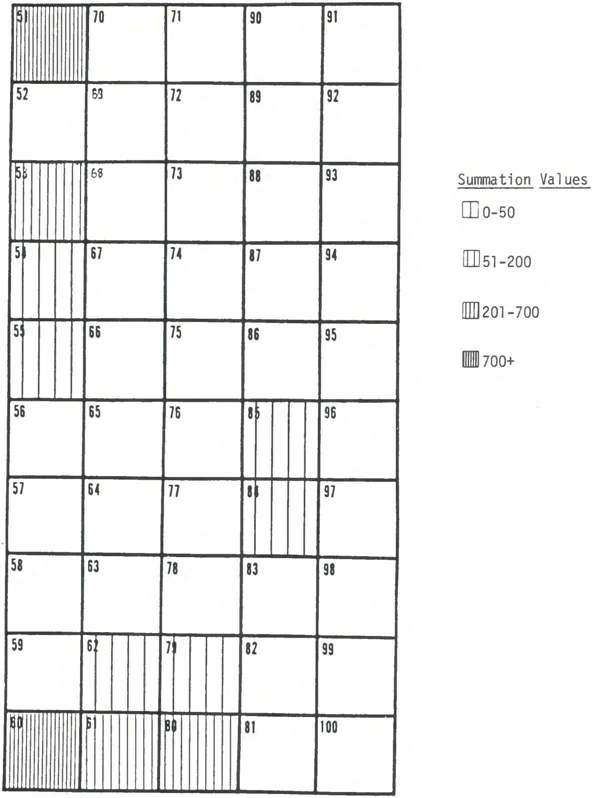

Figure 42. Five month (June-Oct., 1979) summation of the distribution by trapping of S. (D.) abdita in a long leaf pine-turkey oak woods at Gainesville, Florida.

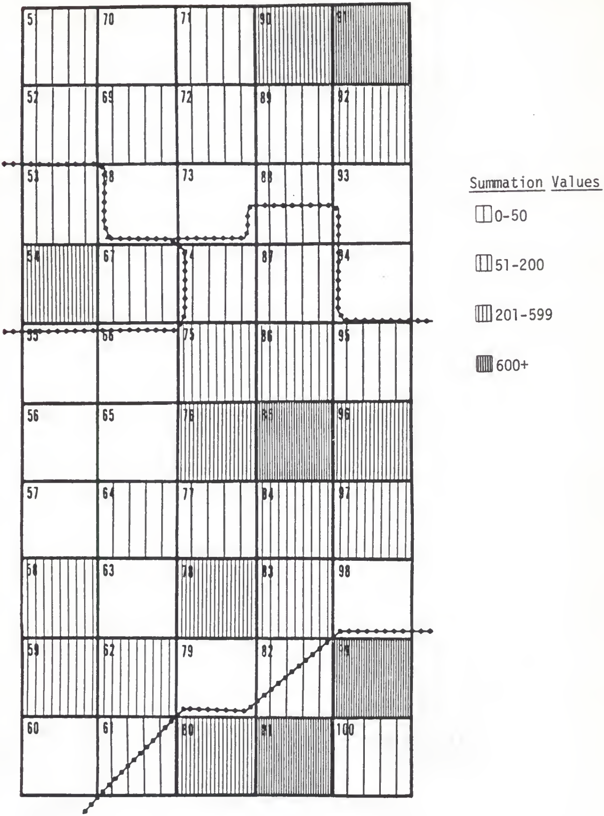

Figure 43. Five month (June-Oct., 1979) summation of the distribution by trapping of S. (D.) xenovenenum in a long leaf pine-turkey oak woods at Gainesville, Florida.

1 ○4	20 ○2	21 ○4 △1	40 ○2 △3	41 ○5 △1
2 ○9	19 ○1 △1	22	39 ○5	42 ○1 △3
3 ○3	18 ○3	23 ○4	38 ○2 △5	43 ○6 △1
4 ○6 △1	17 △1	24 ○4 △1	37 ○6 △2	44 ○3 △2
5 ○6	16 ○4 △1	25 △4	36 ○2 △2	45 ○5
6 ○3 △1	15 ○3	26 ○1	35 ○4	46 ○8 △3
7 ○1 △3	14 ○1 △1	27 △1	34 ○6	47 ○2 △3
8 △2	13 △2	28 ○6 △2	33 ○3 △3	48 ○4 △2
9 ○8	12 ○3 △2	29 ○2	32 ○2 △2	49 ○2 △2
10 ○4 △1	11 ○2	30 ○1 △1	31 ○4 △1	50 ○2 △3

○ S. (D.) carolinensis

△ S. (D.) abdita

Figure 44. Number of months each trap site in an open field at Gainesville, Florida, was positive for ~~three~~ three species of Diplorhoptrum (June 1979-June 1980).

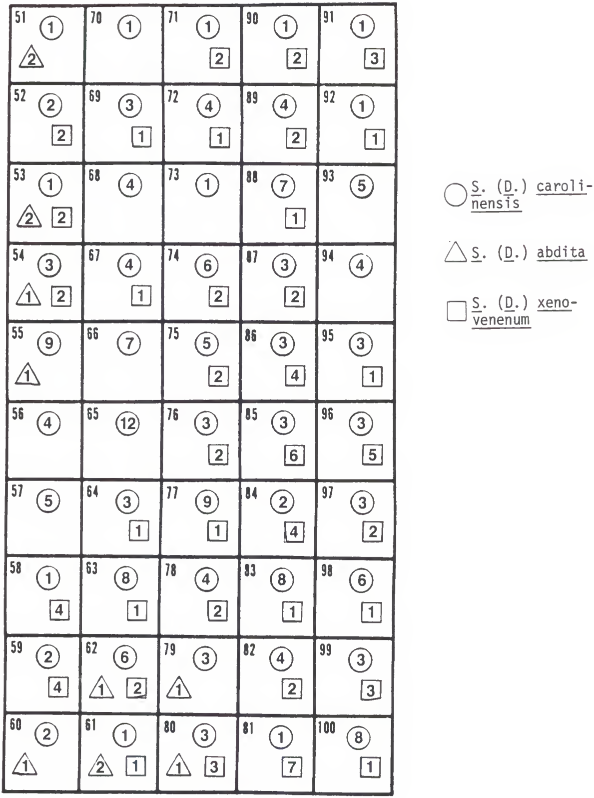

Figure 45. Number of months each trap site in a long leaf pine-turkey oak woods at Gainesville, Florida, was positive for three species of Diplorhoptrum (June 1979-June 1980).

that the ants do not forage far from the nest in the cold, it should be possible to map nest locations more accurately than at other times of the year.

When the winter distribution maps were prepared, however, it was found that many traps were positive, but only once or twice, making pattern discernment impossible.

Figures on the distribution of S. (D.) pergandei and S. (D.) nickersoni were not included, as these species were extremely localized. S. (D.) pergandei appeared only in woods traps with one established nest in or near Meter 70, which included territory in Meters 69-72. S. (D.) pergandei is a sub-dominant. It successfully excluded S. (D.) carolinensis from Meter 70 for an entire year. S. (D.) nickersoni appeared to have an even more scattered distribution except for captures by Traps 8 and 13. It is also a sub-dominant, able (Fig. 40) to exclude S. (D.) carolinensis from Meter 8, but not S. (D.) abdita.

Only Diplorhoptrum species were taken from the field traps in this study, but other ant genera came to the woods traps: Pheidole dentata, Pheidole floridana, Pheidole metallescens, Brachymyrmex depilis and (one collection) Solenopsis geminata. Records of these ants were kept but are not included in this study. It is evident from the approximately 3 to 14% of the traps which captured this group, that the greatest competitors Diplorhoptrum have among other ants are species of Pheidole.

In summary, totally unexpected and extremely large numbers of workers of five Diplorhoptrum species were found in an open field and in long leaf pine-turkey oak woods. Three of the species were new. By constructing a system of assumptions and by summing numbers of positive traps and percentage of those traps for each species, diagrams of

possible nest numbers and territorial boundaries were constructed. *S*. (*D*.) *carolinensis* was the dominant species in both habitats while *S*. (*D*.) *abdita* was common, particularily in the field. Of the less common species, *S*. (*D*.) *xenovenenum* was more often found in the woods, *S*. (*D*.) *nickersoni* was rare in both habitats and *S*. (*D*.) *pergandei* was only in the woods site. This was a beginning study of previously unknown or poorly known species. From the preliminary data no habitat preferences for the various species should be inferred at this time.

Section III
The Mating Flights of S. (D.) pergandei

Solenopsis (Diplorhoptrum) pergandei is the largest species of the subgenus that occurs in Florida. It is also the only species that constructs a visible structure (tumulus) surrounding its nest opening at the soil surface. From June through early September, within 24 hours after a rain, S. (D.) pergandei constructs unique, crenelated tumuli for early morning mating flights.

Tumuli Construction

The tumuli are constructed with passages wide enough for several females to pass (ca. 6 mm) and with walls twice or more their body height (ca. 5-10 mm). I have seen some tumuli 16 cm in diameter. One benefit of these passages is probably an increase in the number of sexuals that can remain at the soil surface in preparation for a flight while still remaining under the protection of the workers. On June 23, 1979, at 4:20 a.m., I observed sexuals massed at the surface even though this flight did not occur until nearly 6 a.m.

A second function of these tumuli is probably to present a flight take-off surface for the departing sexual forms, although I have observed the heavy females climbing up grass blades near the nest.

On mornings when flights did not occur, the ants constructed tumuli of two additional types. These I have called "closed" tumuli and "digging-out" tumuli. The closed tumuli were sometimes constructed on

mornings following rain when flights did not occur. The ants constructed chambers at ground level, then formed a thin roof of soil pellets with worker-sized entrances. No flights were ever observed from these structures.

Digging-out tumuli apparently were for exactly that purpose. Other conditions apparently were not favorable for flights, and the ants were most likely repairing passages which had collapsed with the rain. These tumuli were simply piles of excavated soil deposited near the entrance.

Flight Factors

Preliminary studies in the summer of 1978 suggested that *S.* (*D.*) *pergandei* mating flights did not occur unless there had been measurable precipitation during the previous 24 hours. Data gathered on 30 flights from June to September of 1979, when they ceased in the Gainesville area, showed that 83% (25) of the flights occurred following a rain. On seven additional mornings tumuli were constructed but no flights occurred. The ants frequently constructed closed, digging-out and a few crenelated tumuli on non-flight mornings. This indicated that conditions became unfavorable during the night, or that additional stimuli utilized by the ants to initiate flight were not favorable.

As the summer progressed, mating flights occurred slightly later each week. In late June, flights began at 5:50 a.m. In early August, they were beginning at ca. 6:08 a.m. This suggested that an additional factor potentially triggering flights was light. A commercial light meter was used to attempt light readings at flight times. It was so dark in the half hour before dawn when these ants flew that almost no light values were registered. Readings at 6:41 a.m., shortly after a

flight on September 3, 1979, were 0.05 fc with the probe at ground level facing the sky, 1.0 fc facing the eastern horizon, and 1.6 fc at 45^o to the horizon.

As an alternative to direct light readings, the flight times were recorded and compared with local sunrise times (Fig. 46). Actual flight times recorded were few. I attempted to watch 10-30 nests and rarely saw the actual beginning of a nest flight. It was also so dark that a flashlight had to be used to observe flight activity. It was turned on for a few seconds every five minutes to ascertain flight activity while attempting to keep interference to a minimum. I did notice that I was able by summer's end to arrive at 5:45 a.m. and not miss any of the flights. The graph in Fig. 46 does indeed show a correlation of flight times with time of sunrise. As the days shortened, the flights occurred later in the morning and remained at ca. one half hour before dawn. The occurrence of the wood flights, where dawn was slow to penetrate, at later times than the open meadow flights, also points to light as a triggering factor.

Flight and Post Flight Activities

When moisture and light levels are favorable, a final unknown stimulus (or stimuli) causes the workers in a *S.* (*D.*) *pergandei* nest to begin running about erratically. The winged sexuals become excited and begin to leave the nest. No nest was observed to contain both sexes. Rather, only winged males or winged females were present. The nests containing winged males began flight first. The males, with their smaller and lighter bodies, were quickly in flight. In nests with females flight times were longer. The larger, ponderous females were

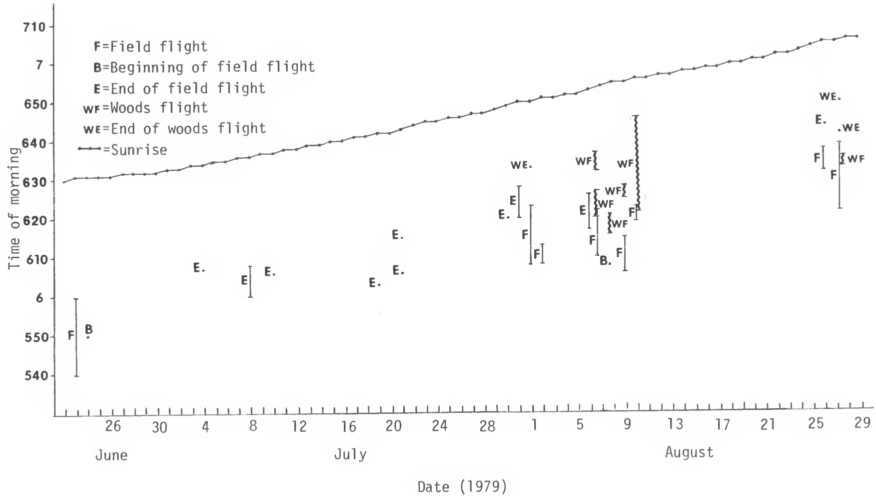

Figure 46. Correlation of S. (D.) pergandei mating flights with times of sunrise in Gainesville, Florida.

also more exposed to predators by their slowness to take wing. I saw both Pheidole workers (June 10, 1979) and a worker of Odontomachus brunneus (Patton) on June 26, 1979, carrying off S. (D.) pergandei females.

Much predation is probably avoided by the erratic movements of the workers. The impetus of worker movements caused them to spread out by the hundreds over the tumulus and within a radius of approximately 5 cm around it. In this area they frequently confronted workers of other species of ants which were immediately attacked. As a result, the large females were protected by a network of workers within the tumulus area.

Although the activities of the workers protected the females quite adequately, after the flight the nest was exposed to extreme danger. The workers did not always close colony entrances and often could be found on the soil surface until midmorning. On three occasions I observed a S. (D.) pergandei nest being destroyed by Solenopsis geminata. I suspect that the only reason more S. (D.) pergandei nests were not attacked was that, after the sun reached them, the tumuli rapidly began to crumble. By 10 a.m. it was virtually impossible to determine whether a flight had occurred: the tumuli had crumbled to a layer of powdered dust on the soil surface.

An unexpected observation was the number of flights which were staged from single nests. Nest locations were stable throughout the summer and workers constructed a new tumulus where the old one had collapsed or had been obscured by rain. It was not uncommon for flights to be initiated from a nest every favorable morning for two months or more. I observed one nest from which sexuals flew for nearly the entire summer.

Initially I hypothesized that mated females were accepted by existent colonies after a flight. Nests near the flight study area contained as many as 20-30 dealate females which I thought were reproducing queens. Observation of nests which had initiated mating flights for several weeks gave another explanation: females were observed with three wings, two wings, one wing and no wings at all during flights. These females, even those with no wings at all, behaved exactly as though they had wings and could take flight. When it became light, and those females with wings had flown, these females retreated back down the nest entrances. Apparently they repeated this behavior flight after flight, progressing from four wings to no wings at all.

The wings of female ants have lines of weakness along which they normally break off after the female has gone on the mating flight. I suspect that jostling in the crowded nest caused some wing breakage and that the loss of one wing was enough to prevent flight. It was these unfortunate females who slowly lost all their wings. I was unable to determine the final fate of these females. It is unlikely any were mated since a nest contained only one sex, and I did not observe males near any tumulus containing females.

By 8 a.m. S. (D.) pergandei females could be found at a second study site: a USDA light trap at the Insects Affecting Man and Animals Laboratory in Gainesville. If rainwater was standing on the trap roof, large numbers of the males often were caught by their wings in the water film, but few ever entered the trap. When rain did not fall for several days, large flights took place. For example, rain occurred on June 30, 1980, after a dry week. The light trap the following morning contained 2,081 S. (D.) pergandei alate females, 5 males and 83 dealated

females. Before I arrived, however, a number of these ants had already been carried off by foraging *Pheidole* workers. Although held in the laboratory several days, no further females shed their wings.

It seemed probable that large numbers of these females were mated, particularily since rain afta a dry period would have coordinated a number of colony flights. Examination of 20 dealated and 20 alate *S.* (*D.*) *pergandei* females by Adrian Glover (USDA Fire Ant technician) revealed that all the dealated females but only two of the alates were mated. These data suggest that the 2,081 *S.* (*D.*) *pergandei* females captured June 30, 1980, were mostly unmated. More information is needed to resolve this question.

Twenty alate *S.* (*D.*) *pergandei* females in groups of five from the light trap were placed on the ground and observed for 15 minutes. Within seconds each female ran quickly into holes and under sticks and leaves and took cover. When the cover was removed 15 minutes later, four females were not found, three had begun to excavate, one had removed her wings, and the remainder had simply remained hidden. Although this behavior indicates females may found nests claustrally, attempts to induce colony founding in the laboratory have not been successful.

In summary, *S.* (*D.*) *pergandei* is the only subterranean Florida *Diplorhoptrum* species which constructs nest structures at the soil surface. It constructs crenelated tumuli from June through early September which are utilized only for mating flights. These tumuli apparently allow more sexuals to remain at the soil surface and offer a surface for flight take-off. Nests produce only males or only females and each nest has many flights during the summer. These flights occur before dawn, and rain in the previous 24 hours is necessary for flight activity.

Section IV
The Role of S. (Diplorhoptrum) as Underground Predators

Preliminary Experiments

The large numbers of Diplorhoptrum found in the ground by Naves trapping (Section II) suggested a further line of research: placing target organisms in the traps to determine whether Diplorhoptrum would prey upon them.

In February, 1976, a 15-trap wood plot and a 25-trap field plot were set up and cabbage loopers were used as bait. Since this was early in my Diplorhoptrum research, I was unaware of the relative inactivity of the ants at this time of year. The loopers were killed by S. (D.) carolinensis, but positive trap numbers remained at only approximately 10 per cent.

This experiment was resumed in April, 1976, when three species of Diplorhoptrum killed and fed upon the loopers. Sometimes, in the 48 hours the trap was down, the ants consumed the entire larva except for the hollowed out head capsule left behind. The predatory Diplorhoptrum species were primarily S. (D.) carolinensis but also S. (D.) pergandei and S. (D.) xenovenenum.

Predation on Fire Ant Females

In June, 1976, fire ant females were collected from local nests and placed as bait in Naves traps. When the traps were recovered in 48 hours, seven of the 15 females had been killed and consumed by

S. (D.) carolinensis workers. In three of these vials the fire ant queen had been consumed except for large pieces of chitin. In the fourth vial, not even the chitinous pieces of the female were left. Of 100 fire ant queens put out in traps August 8, 1980, eight were found dead. Of these, three died of unknown causes, three were found with S. (D.) carolinensis workers, one with S. (D.) xenovenenum workers and one with Pheidole floridana workers. Diplorhoptrum were also found in the traps of eight live queens. In five of those, the Diplorhoptrum workers had been killed and chewed into pieces by the fire ant queen.

Further experiments with fire ant females as bait and the role of the Diplorhoptrum species in the control of this pest species are underway.

Predation on Diaprepes abbreviatus larvae

The Sugar Cane Rootstalk Borer Weevil, Diaprepes abbreviatus (L.), threatens citrus in Florida. The larvae feed on citrus roots and develop undergroud for two to three years. The weevil is presently confined to quarantine areas surrounding Apopka and Davie, Florida.

In light of the above predation studies, and the fact that the Diaprepes larva spends such a long period of its life underground, it seemed logical to suspect that underground predators could have a strong impact on Diaprepes populations.

Preliminary to testing this hypothesis, on July 25, 1979, 100 tuna-baited Naves traps were placed at the tree base, drip line and row middles of four citrus groves in the quarantine area which ranged from fully managed, heavily insecticided groves to a grove untreated pesticidally for 20 years. No Diplorhoptrum were found except in the pesticidally untreated Forest City grove.

Further tests were conducted in the Forest City grove and in a control (non-grove) area to determine Diplorhoptrum populations, but results have been erratic: of 50 tuna-baited Naves traps placed in the Forest City grove on August 23, 1979, only three were positive for ants and none with Diplorhoptrum. Fifty traps in a non-grove control area in woods (subsequently discovered to be old abandoned grove land) were negative.

Of 50 traps placed in the Forest City grove on Sept. 18, 1979, two were positve for S. (D.) carolinensis. In a new control area, 10 traps were positive for S. (D.) carolinensis, two for S. (D.) pergandei and six for S. (D.) xenovenenum.

Results of baiting with tuna indicated that at least three Diplorhoptrum species were present in low numbers in the Apopka area.

To ascertain the role of Diplorhoptrum in Diaprepes larvae control, 50 Naves traps containing Diaprepes larvae were placed in the Forest City grove on Oct. 26, 1979. No control traps were used. No Diplorhoptrum were captured with the larvae. A second set of traps (n=88) with larvae were put down on May 13, 1980 and left for 72 hours. Fifteen traps were put down in a non-grove area as a control. In the grove, Pheidole spp. killed five larvae in the traps, but there was no detectable predatory activity by Diplorhoptrum. In the control area, S. (D.) xenovenenum and S. (D.) nickersoni each attacked and killed a larva. These results were repeated, with Diplorhoptrum spp. again killing two of 15 larvae in the control area on June 9, 1980.

In summary, even in a grove untreated with pesticides for 20 years, Diplorhoptrum populations were low. In control or non-grove areas within the quarantine area Diplorhoptrum populations were higher, and

were capable of killing and eating approximately 15% of the larvae offered in the traps. Although these numbers may not seem significant, if the Diplorhoptrum are capable of killing 15% of the Diaprepes in traps in 72 hours, there is considerable chance that they could kill a significant portion of the larvae over the two or three years the larvae remain below ground.

SUMMARY

This study must be viewed as a preliminary effort in a neglected area of myrmecology. No new species of Diplorhoptrum had been found in North America since 1942. Yet a simple grid pattern of bait traps at Gainesville, Florida, immediately captured three new species. A fourth new species was discovered in randomized sod samples from Dade County, Florida. Thus this group is poorly known in Florida.

The bait trap catches and ancillary studies seem to suggest several other conclusions:

1. Bait trap sampling in the grid study varied between 53 and 75 per cent postive for Diplorhoptrum during the summer months. All trap locations were positive at least occasionally. The data are consistent with information on generalized subterranean predators, which have networks of exploratory tunnels rather than being uniformly present in the soil. Ants that are strictly lestobiotic, always associated with larger ants, could have been expected to show many gaps in their distribution patterns. The data in this preliminary study suggest that there are no distinct gaps in the subterranean spaces patrolled by these ants.

2. Mosaic distribution patterns of the five Diplorhoptrum species captured seem to be suggested by the data. These mosaic patterns are similar to, if not entirely analogous with, the mosaic patterns of arboreal ants in Ghana.

3. Diplorhoptrum species are able to kill and dismember insects much larger than themselves, like large Lepidoptera larvae, fire ant queens, and Coleoptera larva. This is probably due to the potency of their venoms. These data again are consistent with widespread generalized predators, rather than with specialized predation as exhibited by other cryptobiotic ants such as Strumigenys and Smithistruma. The generalized morphological structure of Diplorhoptrum species is also consistent with that of generalized predatory ants, as contrasted with the highly specialized morphologies of the Dacetine ants.

4. Perhaps the most important finding that arises from this study is the significant lack of general biological knowledge of these ants. The ants were previously thought to be specialized, lestobiotic species with sporadic distributions, yet they are now shown to be generalized, widespread, abundant predators in Florida. An important question is whether or not these or other similar ants have similar roles in other areas of North America and of the world. If there is a network of subterranean ants on a worldwide or very widespread basis, then an important component of ecosystems has been neglected.

The paucity of knowledge about Diplorhoptrum is nowhere better seen than in the mating flight data. In spite of much observation, S. (D.) pergandei mating flights were the only flights seen. The other species apparently never construct tumuli. How their sexuals are brought to the surface and what factors trigger their flights is unknown. It is presumed that those species with dark colored sexuals with small eyes and ocelli are diurnal flyers, while species with yellowish sexuals with large eyes and ocelli are nocturnal flyers.

5. Questions this study has raised are the following:

a. What is the physiological and behavioral significance of the venom chemistry of these ants?

b. Is it possible that there are negative correlations between Diplorhoptrum populations and certain other ant populations such as fire ants?

c. Is S. (D.) molesta as widespread and common as it is reported to be in the literature, or are these records partially based on misdeterminations in this taxonomically difficult group?

d. Are Diplorhoptrum populations sometimes abundant enough to have strong impact impact on the populations of pest organisms such as imported fire ants, Sugar Cane Rootstalk Borer larvae, mole crickets, and root knot nematodes?

e. Could Diplorhoptrum species from other areas of North America or of the world be imported into Florida or the southeastern states as biological control agents?

GLOSSARY

Alate--Having wings

Antennal club--The last two segments at the tip of the antenna which, in *Solenopsis*, are enlarged to form a club

Base--Of propodeum, the anterior dorsal surface of the propodeum

Crenelated--Having towers, like a battlement

Cryptobiotic--Life habits which involve remaining hidden, as underground, under debris or in other ways

Dealated--Without wings. In ants, females that have removed their wings after the mating flight but before colony foundation

Declivity--The inclined posterior surface of the propodeum

Excised--Cut out, posterior border of the head is concave

Funiculus--Segmented part of the antenna extending from the end of the scape to the tip of the antennal club

Gaster--That portion of the abdomen, in *Solenopsis*, behind the postpetiole

Infuscation--An area darkened or tinged with brown or black

Lestobiotic--A relationship in which a small ant species nests near a larger ant species and robs the larger ants of their brood or food supplies

Mayrian furrows--Y-shaped mesonotal furrows in males of primitive ants

Myrmecophile--An animal that spends at least part of its life cycle in an ant colony

Occipital border--The posterior or hind margin of the head

Phragmosis--The head or posterior of the abdomen, often in the soldier caste, is truncated to serve as a living plug for a nest entrance

Piligerous puncture--A depression in the exoskeleton in which a hair grows

Polymorphic--Having more than one form, said of ants with more than one worker caste such as majors, minors or soldiers

Polygynous--The presence in one colony of two or more egg-laying queens

Scape--The rigid antennal section which arises from the head and articulates with the funiculus

Stratified--Not random, selected on the basis of previously gathered data

Tumulus--A mound of soil constructed at the entrance of an ant nest and often characteristic of the species

APPENDIX

Table 1. Preferred habitats and nest sites of S. (D.) molesta

State	Habitat	Nest Location	Reference
Arizona	Desert shrub community	--	Chew, 1977; Hunt, 1975
Arkansas	Cotton fields, many locales	--	Whitcomb et al., 1972; Warren & Rouse, 1969
Colorado	5,600-6,500 ft, short grass prairie, pinyon-cedar, oak woods, in clay	Under rocks	Gregg, 1963
Idaho	S. molesta-Agropyron repens & L. niger-Salsole pestifer communities	Moist areas, under flat rocks	Cole, 1933, 1936
Illinois	Dry or wet areas	Grass, mounds, under stones, debris beneath bee combs	Amstutz, 1943 Frison, 1926
Louisiana	Pastures	--	Howard & Oliver, 1979
Michigan	High fields, old fields, rocky beach	--	Talbot, 1953, 1965; Gaige, 1914; Gregg, 1972
Montana	Grasslands	Under rocks	Borchert & Anderson, 1973
N. Carolina	17 habitats of field and forest	Under stones or cover in ground	Carter, 1962a and 1962b
N. Dakota	Mostly grasslands	Under stones	Wheeler & Wheeler, 1963
New Jersey	Open sunny woods, clearings, woods borders	--	Wheeler, 1905a
New York	Open grass, gardens	--	Davis & Bequaert, 1922; Fitch, 1856
Ohio	Woods and fields	Rotten wood, under stones	Wesson & Wesson, 1940
S. Carolina	Pine plantation, oak pine, hardwood hammock, old field	Logs, stumps, soil	Van Pelt, 1966
Tennessee	Mostly dry grassy areas; dense shade & open areas, except mtn peaks, prefer open, dry	Beneath stones, wood	Cole, 1940; Dennis, 1938
Utah	Foothills, lower mtn slopes	Under fairly large stones	Grundmann & Peterson, 1953; Cole, 1942
Virginia?	3,500-5,500 ft	In soil, under rocks	Van Pelt, 1963
W. Virginia	Apple orchards	Compacted soil in & near roads, under roots	Jaynes & Marucci, 1947

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BIOGRAPHICAL SKETCH

Catherine R. Thompson was born November 21, 1952, in Boston, Massachusetts. Her family moved to Cedar Falls, Iowa, where she attended Malcolm Price Laboratory School. In June, 1971, she graduated from Northern University High School in Cedar Falls.

She attended the University of Northern Iowa in Cedar Falls, during the summers of 1971, 1972, 1973 and the fall of 1973. She attended Cornell College during the remainder of 1971, 1972, 1973 and part of 1974, graduating in June, 1974, with a B.A. in biology and English.

In September, 1974, she entered graduate shcool in the Department of Entomology and Nematology at the University of Florida. She received the M.S. degree in June, 1976, and commenced work toward the Doctor of Philosophy degree in entomology and a minor in botany at the University of Florida.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Dr. William F. Buren, Chairman
Professor of Entomology and Nematology

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philsophy.

Dr. Dana G. Griffin III
Professor of Botany

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philsophy.

Dr. Reece I. Sailer
Graduate Research Professor of
Entomology and Nematology

This dissertation was submitted to the Graduate Faculty of the College of Agriculture and to the Graduate Council, and was accepted as partial fulfillment of the requirements for the degree of Doctor of Philosophy.

August, 1980

Jack L. Fry

Dean, College of Agriculture

Dean, Graduate School